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Essays on Institutional Investors and Firm Behavior

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Thesis submission for the degree of Doctor of Philosophy

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Abstract

In this thesis, I develop improved arguments and methods for interpreting and characterizing the effect of institutional investors on the behavior of firms.

In Essay 1, I provide a novel set of theoretical results for characterizing the effect of institutional investors on firm behaviors related to greenhouse gas emissions. To do so, I identify a set of unique directional changes in firm behaviors related to greenhouse gas emissions that arise from the controlling owners of firms changing from short-term profit maximizers to one of five other competing objective functions: long-term profit maximization, short-term common ownership, long-term common ownership, socially responsible investment and stakeholder theory.

In Essay 2, I refine what I call the “power-based approach” to estimating and interpreting the effect of an agent (such as an institutional investor) on the social choice of a group of agents (such as a firm). To summarize, “power-based approaches” are an applied empirical practice that involves estimating, interpreting and characterizing OLS regression coefficients from linear regressions of group choices on a proxy for the “power” of an agent, or group of agents, of interest. Based on this applied empirical practice, I develop a framework that assists in interpreting the estimated effects, developing bounds on effects, constructing identification arguments and developing measures of “power”, and demonstrate its usefulness through an application to the results of Ashraf, Field, and Lee (2014).

In Essay 3, I provide a critical review of the literature on firm behavior and firm, investor and manager objective functions. First, I provide a novel taxonomy of maximization problems based on theories of the firm and theories of firm, investor and manager objective functions. I then assess if the recent, highly cited theoretical literature explores whether unique firm behaviors are implied by different maximization problems or objective functions, finding that most of these papers compare only profit maximization and some other objective function. In combination with a similar, but preliminary, finding about the empirical literature, I reach the preliminary conclusion that only short-term profit maximization can be ruled out as the explanation for the results, and that none of the maximization problems can explain all of the results. Therefore, despite the leaps forward taken in this literature over the last decade, there appears to be considerable opportunity for future research in this area.

Publications

A working paper based on Chapter 1 of this thesis is currently published on SSRN with Associate Professor Anthony Asher and Professor Arghya Ghosh. The reference is shown below.

Annabel, R., A. Asher, and A. Ghosh (2022, November). Company-Level GHG Emissions And An Institutional Investor's Active Ownership Objective: Long-Term Shareholder, Socially Responsible Investor, Common Owner Or Stakeholder-Oriented Shareholder?

Presentations

Various versions of Chapter 1 of this thesis were presented at the following conferences:

- the 29th CEPAR Colloquium, co-hosted by CEPAR and the School of Risk & Actuarial Studies, UNSW Business School, Sydney,
- the 12th Financial Markets and Corporate Governance Conference, hosted by Monash Business School, Monash University, Melbourne,
- the 29th Global Finance Conference, hosted by The Global Finance Association and the University of Minho, Braga,
- the inaugural Markets, Contracts and Organizations conference, hosted by the Research School of Economics, Australian National University, Canberra, and
- the 2023 Econometric Society Australasia Meeting, hosted by the School of Economics, UNSW Business School, Sydney.

A presentation based on aspects of this thesis was made to the Australian Prudential Regulation Authority and the Reserve Bank of Australia under the terms of the Brian Gray Scholarship program.

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Contents

List of Figures	viii
List of Tables	ix
1 Introduction	1
2 Identifying an investor’s active ownership objective when firms emit greenhouse gas emissions	4
2.1 Introduction	5
2.2 An example of the active ownership identification problem	8
2.2.1 Model set-up	9
2.2.2 Active ownership objectives	12
2.2.3 The benchmark model	15
2.2.4 Comparison of the results from the alternative models to the results of the benchmark model	15
2.3 A solution to an active ownership identification problem	19
2.3.1 Mitigation and adaptation	20
2.3.2 Zero exposure to damage	24
2.3.3 High willingness to pay and non-monotone revenue	28
2.3.4 Imperfectly competitive, commonly owned, exclusive suppliers	31
2.4 Conclusion	38
3 A simple, power-based framework for analyzing an agent’s effect on social choices	42
3.1 Introduction	43
3.2 Framework: Connecting social choices to power	48
3.2.1 The power weighted social choice function	48
3.2.2 Micro-foundations for the power weighted social choice function	50
3.2.3 Example	52
3.3 Empirics: Implications and use with a binary treatment variable	55
3.3.1 Preliminaries	55
3.3.2 Interpreting results	57

3.3.3	Bounding treatment effects and testing assumptions through experimental design	64
3.3.4	Structural estimation and measuring power for identification	68
3.4	Conclusion, discussion and suggestions for future research	74
4	Firm, investor and manager objectives, and firm behavior	77
4.1	Introduction	78
4.2	Taxonomy of maximization problems	80
4.3	Theory and alternative objective functions	93
4.3.1	Common ownership	93
4.3.2	Social responsibility	96
4.3.3	Stakeholder theory	99
4.4	Conclusion, discussion and suggestions for future research	101
5	Conclusion and Discussion	106
A	Appendices for Chapter 2	110
A.1	Model set-up	110
A.1.1	Profits of Sector Y and wages	110
A.1.2	Long-term profit expressions for Sector Q and Sectors R_n	110
A.1.3	Demand functions	111
A.1.4	Emissions tax	111
A.2	Models for Section 2.2	113
A.2.1	The benchmark model	113
A.2.2	Long-term profit maximizer	113
A.2.3	Short-term common owner	114
A.2.4	Long-term common owner	115
A.2.5	SRI	115
A.2.6	Stakeholder-oriented shareholder	116
A.3	Models for Section 2.3	119
A.3.1	The benchmark mitigation-adaptation model	119
A.3.2	Long-term profit maximizer with mitigation and adaptation	120
A.3.3	Short-term common owner with mitigation and adaptation	121
A.3.4	Long-term common owner with mitigation and adaptation	123
A.3.5	SRI with mitigation and adaptation	124
A.3.6	Stakeholder-oriented shareholder	126
A.3.7	Separating the long-term common owner and the SRI	129
A.3.8	Models and results for imperfectly competitive, commonly owned, exclusive suppliers	133
A.4	Discussion and limitations	140

A.4.1	Further results assuming a common discount factor or common intra-industry incentive	140
A.4.2	Corporate governance process	141
B	Appendices for Chapter 3	142
B.1	Robustness tests for Section 3.3.2 and Section 3.3.3	142
B.2	Additional results for robustness tests in Appendix B.1	152
C	Appendices for Chapter 4	154
C.1	Extended taxonomy	154
C.2	Objective functions and product market competition	160
C.3	Ongoing survey of the empirical literature	163
C.3.1	Reduced-form approaches	164
C.3.2	Structural approaches	169
C.3.3	Case studies	170
	Bibliography	190

List of Figures

2.1	Revenue and the location of the benchmark model quantities based on willingness to pay.	29
2.2	Movements in model outcomes for each active ownership objective relative to the short-term profit maximizer under different industry conditions.	39
3.1	Payoff matrix for the family's fertility choice problem.	53
3.2	Screenshot of Table 2 from AFL.	62

List of Tables

3.1	Mean (RMSE) of differences between \bar{Y}_B and estimates of $\mathbb{E}(Y_{i,B})$ under various approaches to estimating β_0	72
3.2	Mean (RMSE, Accuracy) of differences between $\bar{Y}_A - \bar{Y}_B$ and estimates of $\mathbb{E}(Y_{i,A} - Y_{i,B})$ under various approaches to estimating β_1	73
3.3	Comparison of power-based approaches for explaining social choices	75
4.1	Objective functions from the theory of common ownership (1)	94
4.2	Objective functions from the theory of common ownership (2)	95
4.3	Objective functions from the theory of social responsibility (1).	97
4.4	Objective functions from the theory of social responsibility (2).	98
4.5	Objective functions from stakeholder theory	100
B.1	Percentage of sample in Responders.	144
B.2	Average treatment effect estimates using different Responder classifications relative to the classification used by AFL (1).	144
B.3	Adjusted average treatment effect estimates using different Responder classifications relative to the classification used by AFL (1).	147
B.4	Adjusted average treatment effect estimates using different Responder classifications relative to the classification used by AFL (2).	148
B.5	Effects of treatment on receiving injectables conditional on voucher use.	150
B.6	Adjusted average treatment effect estimates using different Responder classifications relative to the classification used by AFL (3).	152
B.7	Average treatment effect estimates using different Responder classifications relative to the classification used by AFL (2).	153

Chapter 1

Introduction

The economic, environmental, social and political impacts of firms have in recent times received considerable attention from academics, regulators and society more generally. Many have investigated the economic opportunities and costs posed by mergers and acquisitions, industry concentration, and common ownership (Australian Federal Government, 2021; Cave-naile, Celik, and Tian, 2021; FTC, 2018, 2023; Gerardi, Lowry, and Schenone, 2024; Schmalz, 2018, 2021; United States House of Representatives, 2020). Many have also investigated the environmental, social and political impacts of firms, such as firms' greenhouse gas emissions, provision of potentially harmful products, workplace health and safety record, and corporate political activities (see, for example, Azar, Duro, Kadach, and Ormazabal, 2021; Bertrand, Bombardini, Fisman, Hackinen, and Trebbi, 2021; Bertrand, Bombardini, Fisman, Trebbi, and Yegen, 2023; Chen, Dong, and Lin, 2020; Dyck, Lins, Roth, and Wagner, 2019). In their explanations for firm, or more particularly corporate, behavior in these areas, many have focused on the role and impact of shareholders in relation to firm behavior (see, for example, the reviews of Boyd and Solarino, 2016; DesJardine, Zhang, and Shi, 2023; Edmans, 2014; Gerardi, Lowry, and Schenone, 2024; Gillan, Koch, and Starks, 2021; Schmalz, 2018, 2021). In particular, these recent shareholder-based explanations for firm behavior often focus on the role and impact of institutional investors (see, for example, the reviews of Boyd and Solarino, 2016; DesJardine, Zhang, and Shi, 2023; Gerardi, Lowry, and Schenone, 2024; Gillan, Koch, and Starks, 2021; Schmalz, 2018, 2021).

An important part of explaining the effect of institutional investors on firm behavior has been characterizing the effect of institutional investors on firm behavior.¹ Generally, this has been

¹Other important parts of explaining the effect of institutional investors on firm behavior, which are not the focus of this thesis, include establishing that institutional investors have the ability and incentives to affect firm behavior, and identifying the means and mechanisms via which institutional investors affect firm behavior. Since the former may be considered a precondition for institutional investors having any (i.e., a non-zero) effect on firm behavior and that expecting institutional investors to have a non-zero effect on firm behavior may be considered

approached by postulating an objective (or utility) function that characterizes institutional investors' preferences over firm behavior. For example, some have characterized the observed effects of institutional investors on firm behavior as-if institutional investors are long-term owners (or, more specifically, long-term profit maximizers) (see, for example, Dimson, Karakas, and Li, 2023; Gloßner, 2019; Kim, Kim, Kim, and Park, 2019), whilst others have characterized the observed effects of institutional investors on firm behavior as-if institutional investors are socially responsible investors (see, for example the review of Gillan, Koch, and Starks, 2021), common owners (see, for example, the reviews of Gerardi, Lowry, and Schenone, 2024; Schmalz, 2018, 2021), or stakeholder-oriented shareholders (Klettner, 2021).

In doing so, however, the existing literature suffers from two important limitations, which I contribute to addressing in Chapters 2, 3 and 4. The first problem, which is largely a theoretical problem and for which I provide evidence in Chapter 4, is that, when attempting to characterize institutional investors by an objective function summarizing their preferred firm behavior, the current theoretical and empirical literature tends to consider only two possible objective functions; profit maximization and one other. As a result, as is briefly discussed in Chapter 4 and more formally shown in Chapter 2 in models where firms emit greenhouse gas emissions, many plausible and important alternative characterizations for the theoretical and empirical results remain unexplored. To make progress towards addressing this problem, I make the following two contributions. First, in Chapter 2, I present a novel set of theoretical results for uniquely characterizing the effect of institutional investors on firm behaviors related to greenhouse gas emissions using the characterizations commonly considered in the literature. Second, in Chapter 4 and to assist in further research on this problem, I provide a taxonomy of firm-level maximization problems for characterizing agents' preferences for firm behavior based on theories of the firm and theories of the objective functions of firms, investors

important to justifying attempts to characterize the effect of institutional investors on firm behavior, I briefly suggest institutional investors are likely to have a non-zero effect on firm behavior for the following four reasons. First, the ability of institutional investors to form small coalitions to affect firm behavior has likely increased since institutional investor ownership of publicly-listed corporations is significant and becoming increasingly concentrated, both in the US (Amel-Zadeh, Kasperk, and Schmalz, 2022; Backus, Conlon, and Sinkinson, 2021) and across the globe (see papers cited in Klettner, 2021), whilst institutional investors are arguably becoming more homogeneous due to the rise of index investing (Backus, Conlon, and Sinkinson, 2021). Supporting evidence for institutional investors' increased ability to form coalitions includes the formation of the United Nations Principles of Responsible Investment, the Climate Action 100+, the Council for Institutional Investors, and the rise of proxy advisors (see, for example, Shu, 2024), both of whom could, and sometimes explicitly claim to, serve as platforms for coordination among institutional investors. Second, as institutional investors' assets under management have grown, perhaps also in real terms (in the US, see, for example, Lewellen and Lewellen, 2022), and their portfolios become more illiquid as index investing also grows, their economic incentives to affect firm behavior have increased (Lewellen and Lewellen, 2022) whilst, given their increased capacity to affect firm behaviors, the social pressures to do so have also arguably increased. Third, as can be seen in the empirical results covered in Chapter 4, many empirical papers find that the effects of institutional investors on firm behaviors are statistically significant. Thus, even if the effects are not economically significant and assuming identification problems have been adequately addressed, the effects of institutional investors on firm behavior are at least statistically detectable (i.e, the effects are non-zero). Finally, institutional investors often publicly claim they will influence firm behavior in their governance policies and media statements. For direct examples, see ABP (2020), BlackRock (2022), BlackRock's Global Executive Committee (2021), and CalSTRS (2021), and for a broad empirical analysis focused on stewardship, see Klettner (2021).

and managers.

The second problem, which is largely an econometric problem, is that, for one of the most common empirical methods² used to analyze the effect of institutional investors on firm behavior, there has not been, to the best of my knowledge, any research on the micro-foundations, proper interpretation and structural estimation of the econometric specification underlying this method.³ The common empirical method is what I call "social choice power regressions." To summarize, social choice power regressions tend to involve the following three steps. First, OLS is used to estimate a linear regression of a social choice, such as a firm choice, on a proxy for the power of the an agent, or group of agents, of interest, such as institutional investors. Second, the estimated coefficient of the proxy for the power of the agent of interest is interpreted as if it reflects, or carries some information about, the preferences of the agent of interest. Finally, the agent of interest is characterized based on the sign of the coefficient. In order to provide micro-foundations, and assist with the proper interpretation and structural estimation of social choice power regressions, I develop what I call a "power-based framework" for analyzing the effect of an agent on social choices in Chapter 3. Using a binary treatment variable as the proxy for the power of the agent of interest, I then provide results for properly interpreting the estimated effects, developing bounds on effects, and developing measures of "power" for use in structural estimation. To demonstrate the usefulness of these results, I apply them to Ashraf, Field, and Lee (2014), who conducted a field experiment in which wives are given a voucher for contraception either with their husband present or in secret from their husband.⁴

The rest of this thesis proceeds as follows. In Chapter 2, I derive a set of novel theoretical results for providing unique characterizations of the effect of institutional effects on firm behavior when firms emit greenhouse gas emissions. In Chapter 3, I develop a power-based framework for analyzing the effect of an agent on social choices and demonstrate its usefulness by revisiting results from Ashraf, Field, and Lee (2014). In Chapter 4, I provide a critical review of the literature characterizing the effects of institutional investors on firm behavior. In Chapter 5, I conclude, discuss the findings of this thesis and suggest areas for future research.

²See Appendix C.3 for more detail on this method and other commonly used empirical methods for investigating the effect of institutional investors on firm behavior.

³As outlined in Chapter 3, this method also appears to be used in many literatures concerned with the effect of an agent on social choices. Therefore, the contribution by developing this method also extends to those literatures.

⁴Given the broad applicability of the framework, Ashraf, Field, and Lee (2014) was deemed the most suitable paper for application of the framework despite Ashraf, Field, and Lee (2014) focusing on households rather than firms. In Chapter 5, I discuss the use of the framework for institutional investors and firms.

Chapter 2

Identifying an investor's active ownership objective when firms emit greenhouse gas emissions

Abstract

The impact of institutional investors on the behavior of their portfolio firms has received significant attention, and increasingly so in relation to climate change. Some are concerned that institutional investors act as common owners. However, in their active ownership policies, institutional investors often say they are long-term shareholders, socially responsible investors, or stakeholder-oriented. We investigate, theoretically, the different implications of such active ownership objectives for firm's economic behavior and environmental outcomes when firms emit greenhouse gas emissions. We find that, if firms are exposed to damage from emissions, then all the aforementioned active ownership objectives can lead to a reduction in emissions and quantities, casting doubt on explanations that identify any particular active ownership objective with reductions in firm-level emissions and quantities. We then find separating conditions for the various active ownership objectives based on firm behavior and environmental outcomes under different industry conditions.¹

¹A working paper, Annabel, Asher, and Ghosh (2022), based on Chapter 1 of this thesis is currently published on SSRN with Associate Professor Anthony Asher and Professor Arghya Ghosh.

2.1 Introduction

Institutional ownership has reached significant levels globally. This has led some to suggest that institutional investors may play a significant role in addressing greenhouse gas ('GHG') emissions (e.g., Andersson, Bolton, and Samama, 2016; Bank of England, 2020; OECD, 2017; United Nations Climate Change Conference, 2021). Many institutional investors have outlined an approach to do so in their active ownership policies. These approaches appear to follow familiar and perhaps well-intentioned corporate objectives: long-term shareholder value maximization (e.g., CalSTRS, 2021),² socially responsible investment ('SRI') (e.g., ABP, 2020), and stakeholder theory (e.g., BlackRock, 2022). High levels of institutional ownership, however, have also led to concerns about institutional investors implementing common ownership³ objectives, which, coincidentally, leads to the consideration of the effect of negative externalities, such as GHG emissions, on portfolio firms.⁴

In this paper, we find circumstances under which each of the active ownership objectives mentioned in the previous paragraph⁵ lead to directionally different firm-level behaviors if firms emit GHG emissions.⁶ First, we model GHG emissions as an inseparable negative externality⁷ to show that a negative correlation between institutional investor influence and firm-level GHG emissions⁸ could be interpreted as consistent with every active ownership objective. We do, however, also show that the stakeholder-oriented shareholder is the only active owner type who may, but does not necessarily, increase quantities and emissions relative to the short-term profit maximizer. Thus, the stakeholder-oriented shareholder can be separated from other active ownership types when a positive correlation between institutional investor influence and firm-level quantities and emissions is observed.

²Throughout the paper, we refer to this as long-term profit maximization

³That is, as owners of multiple companies, within the same industry but also across industries, who make decisions with a portfolio-level decision frame with the objective of maximizing portfolio-level profits.

⁴See, for example, Hansen and Lott (1996) and Harford (1997)

⁵Specifically, long-term profit maximization, SRI, stakeholder-oriented shareholders and common owners. We split common ownership into short-term common ownership and long-term common ownership to separate the anti-competitive incentive from the incentive to reduce damage, which arrives sometime in the future, to firms in the investment portfolio.

⁶Rather than results that focus on the magnitude of firm-level behaviors, we focus on deriving results that lead to directionally different firm behaviors because we believe the conditions required are more plausible for empirical application. As can be seen from the equilibria of the models, theoretical results about unique ranges of magnitudes for firm behaviors require the specification of bounds on the ranges in terms of parameters that seem less likely to be known in empirical applications (other than the case of a zero bound, which, of course, is therefore not sensitive to the parameters). However, assuming the empirical approach can identify the investor's preference for firm-level behavior, the bounds on this range would need to be specified for hypothesis testing. Therefore, empirically testing hypotheses that rely results about unique ranges of magnitudes for firm-level behavior seems less plausible. For similar reasons, results for unique values of the magnitude of firm behavior seem even more implausible.

⁷We use a similar approach to that used by the papers cited in the hypothesis development of Azar, Duro, Kadach, and Ormazabal (2021), Hansen and Lott (1996), and Harford (1997).

⁸Theoretically represented by the difference between the equilibrium outcome for each active ownership objective relative to a short-term profit maximizer.

Second, we introduce industries in which firms can mitigate or adapt to the damage from GHG emissions. Mitigation reduces a firm's emissions and thus benefits all exposed to damage emissions, whilst adaptation reduces damage to the firm only. We find that all active ownership types increase mitigation relative to the short-term profit maximizer, except the short-term common owner. Thus, the short-term common owner can be differentiated from the other active owners. This result is driven by the myopia of short-term common owner; they do not consider the future, so they do not invest in mitigation or adaptation beyond that required by regulation.

We then derive three further industry conditions to separate the remaining active ownership objectives: long-term shareholders, SRIs, long-term common owners and stakeholder-oriented shareholders. The first set of industry conditions is when there is no exposure to damage from emissions for firms in an industry. In such cases, the long-term profit maximizer can be separated from the other active ownership objectives by no increase in mitigation. This result is driven by the private good nature of adaptation and public good nature of mitigation; the long-term shareholder only cares about the payoffs to the firm, so, if the long-term shareholder is not exposed to damage, then they do not mitigate beyond that required by regulation. If, in addition to the firm not being exposed to damage, the benefit to stakeholders from additional production is larger than the incentive to mitigate arising from the damage to stakeholders, the stakeholder-oriented shareholder can be differentiated by an increase in quantities and emissions whilst also increasing mitigation.

The second set of industry conditions is when consumers have high willingness to pay and revenue is a non-monotonic function of quantities.⁹ When willingness to pay is high, the short-term profit maximizer chooses quantities above that which maximizes revenue. Thus, the effect on revenue of decreasing quantities (as is done by both the SRI and long-term common owner) could be positive or negative. We find in such a circumstance that, if the common ownership incentives are sufficiently large, then SRIs increase revenue and long-term common owners decrease revenue.

The final set of industry conditions is when there are imperfectly competitive, commonly-owned, exclusive suppliers. In such a circumstance, common owners now not only have the horizontal incentive to reduce production but also the vertical incentive to expand production. As a result, common owners expand production and increase emissions when the horizontal incentive is sufficiently low and the vertical incentive is sufficiently high. Otherwise, common owners reduce quantities and emissions.

Our paper contributes to the considerable literature on investor objectives and firm-level be-

⁹Willingness to pay is the maximum price at which a consumer is willing to buy a product. Non-monotone revenue arises naturally when i) the maximum willingness to pay is finite, known as a choke price, and ii) prices approach zero as quantities become large.

havior recently reviewed, for example, by Schmalz (2018, 2021) and Backus, Conlon, and Sinkinson (2019) in respect to common ownership, and Gillan, Koch, and Starks (2021) in respect to the finance literature on SRI, ESG, CSR and stakeholder theory. Specifically, our principal contribution to the theoretical literature¹⁰ on common ownership, SRI, stakeholder theory, and long-term profit maximization is investigating the circumstances under which each of these investor objectives may lead to different firm behavior, particularly in the context of inseparable negative production externalities such as GHG emissions. In doing so, we also contribute to the empirical literature in two ways. First, our results can be used as hypotheses in future empirical studies that aim to categorize institutional investors as acting according to an active ownership objective. Second, as will be done throughout the paper in relation to the existing empirical literature on institutional investor influence and firm-level GHG emission,¹¹ we also provide guidance for the interpretation of empirical results intended to shed light on investor objectives.

The rest of the paper proceeds as follows. In Section 2.2, we use models from the field of industrial organization and adopt different active ownership objectives to show that the results in nascent literature on GHG emissions and institutional investor influence could be consistent with institutional investors acting according to several active ownership objectives. In Section 2.3, we first extend the models in Section 2.2 to allow firms to mitigate and adapt to climate change, which creates some separation of active ownership objectives, then consider the industry conditions that allow further separation of active ownership objectives. By combining these results, a set of predictions to differentiate the active ownership types under various industry conditions and using various outcomes is generated. In Section 2.4, we conclude.

¹⁰For recent theoretical contributions, not necessarily concerning negative externalities, in each area see Azar and Vives (2021a), López and Vives (2019) and Antón, Ederer, Giné, and Schmalz (2023) on common ownership, Hart and Zingales (2017) and Broccardo, Hart, and Zingales (2020) on SRI, and Magill, Quinzii, and Rochet (2015) and Freeman, Phillips, and Sisodia (2020) on stakeholder theory

¹¹These papers include Shive and Forster (2020), Azar, Duro, Kadach, and Ormazabal (2021), Akey and Appel (2019), Naaraayanan, Sachdeva, and Sharma (2020), Benlemlih, Arif, and Nadeem (2022). For detail about empirically testing some of hypotheses we generate in this paper, please see the aforementioned papers.

2.2 The active ownership identification problem in the context of GHG emissions

Recently, to the best of our knowledge, there have been five (working) papers published containing results for the quantitative association between GHG emissions and institutional investor¹² influence: Shive and Forster (2020), Azar, Duro, Kadach, and Ormazabal (2021), Akey and Appel (2019), Naaraayanan, Sachdeva, and Sharma (2020), Benlemlih, Arif, and Nadeem (2022). All papers find a negative association between institutional investor influence and GHG emissions.¹³ In light of this information, the questions raised by this paper are; if we are seeking to identify what type of active owner institutional investors are acting as, what can we conclude with this information? Are institutional investors' long-term shareholders, socially responsible investors, or stakeholder-oriented as they claim? Or are they common owners? In this section, by modeling GHG emissions as an inseparable negative externality similar to the papers used in the hypothesis development of Azar, Duro, Kadach, and Ormazabal (2021),¹⁴ we show, subject to some assumptions about the significance of damage from climate change, that the answer to these questions is: the information suggests they could be any of those and may only rule out institutional investors being short-term profit maximizers.

To show this, we proceed as follows. First, we construct a benchmark model where firms are short-term profit maximizers. We then construct alternative models in which institutional investors instruct firms to adopt other objective functions. Finally, we compare equilibrium firm-level emissions in the alternative models to the benchmark model. As expected, we find that equilibrium firm-level emissions are lower in every alternative model than in the benchmark model if damage from climate change is considered to be sufficiently large. Therefore, according to these models the observed negative association in the literature on GHG emissions and institutional investor influence could be a result of adopting any of the active ownership policies represented in Section 2.2.2 below, except short-term profit maximization.

¹²Of various types: mutual funds, the Big Three asset managers (BlackRock, State Street, Vanguard), hedge funds and those institutional investors associated with the Boardroom Accountability Project.

¹³Akey and Appel (2019) and Naaraayanan, Sachdeva, and Sharma (2020) also report results for the association between institutional investor influence and investments in abatement. We deal with this further below when we introduce a model with mitigation. We see abatement as akin to mitigation.

¹⁴Hansen and Lott (1996) and Harford (1997).

2.2.1 Model set-up

We consider a partial equilibrium model¹⁵ of an economy as follows. There are N goods; q , y , and $N - 2$ other goods denoted r_n where $n = 1, 2, \dots, N - 2$. These goods are produced by N sectors; Sector Q , Sector Y , and a sector for each r_n denoted Sectors R_n . There is perfect competition in Sector Y which produces the numeraire good y . There is Cournot duopoly in homogeneous goods in Sectors Q and R_n with $I = 2$ firms in each industry, with each firm in Sector Q denoted $i = 1, 2$ and each firm in Sector R_n denoted $k_n = 1, 2$.

There is one factor of production, labor denoted L , and it is mobile across sectors. Sectors Q and R_n produce good q using r_n with the production technologies $Q = \frac{L_Q}{c}$ and $R_n = \frac{L_{R_n}}{c}$, respectively. Sector Y produces good y using L with the production technology $Y = L_Y$. Total labor is restricted to $L_Q + L_Y + \sum_n L_{R_n} = L$. Wages per unit of labor is represented by w .

Production of goods y and r_n do not result in emissions. But production of good q does result in emissions for each firm, e_i , where the units for emissions per unit of production are chosen so that $q_i = e_i$. These emissions add to the current stock of emissions in the atmosphere, E_0 , so that total emissions in the atmosphere is $E = E_0 + e_1 + e_2$. Emissions result in damage to every firm in Sectors Q and R_n ¹⁶ at some future time point. The damage to each firm in Sectors Q and R_n is given by $\delta\gamma_f E$, where $0 < \delta \leq 1$ represents the time discount rate and $\gamma_f > 0$ represents the severity of damage to an individual firm. To address the damage, government has set a tax, $t > 0$, per unit of emissions.¹⁷

Combining the information above, the (long-term) profits of firm i in Sector Q are therefore given by:

$$\tilde{\pi}_{Q,i} = (p_Q - c)q_i - te_i - \delta\gamma_f E = (p_Q - c - t)q_i - \delta\gamma_f E = \pi_{Q,i} - \delta\gamma_f E \quad (2.1)$$

since $q_i = e_i$, and where p_Q is the price in Sector Q and $\pi_{Q,i}$ represents firm profits without damage from emissions but inclusive of any taxes imposed by the government for producing

¹⁵Thus, the model does not account for wealth effects. For general equilibrium models of common ownership that do account for wealth effects, see Azar and Vives (2021a) and Azar and Vives (2019), who account for wealth effects arising from labor income and interest income. Both find that higher common ownership leads to lower output under realistic parameterizations. Also relevant in this regard is Gans, Leigh, Schmalz, and Triggs (2019), who account for ownership-related income and show that asymmetric ownership leads to higher prices than if ownership were symmetric.

¹⁶For simplicity, we ignore damage to Sector Y .

¹⁷That is, we assume taxes are exogenous and do not model the tax choice for the government. In the model we have constructed, however, one could raise the concern that it is not necessarily the case that the government would choose taxes, $t > 0$, instead of subsidies, $t < 0$, because it is possible that the level of production in oligopolies is below the production level that maximizes welfare net of damage from emissions. In addition to suggesting that taxes are a realistic assumption in this circumstance, we address this concern by noting that, if taxes were endogenous and set optimally by a government in our model, then one requires the assumption that $a < 3\delta\gamma + c$ to ensure a tax, i.e. $t > 0$, would be set by the government. See Appendix A.1.4 for working.

emissions. Similarly, the (long-term) profits for firm k_n in Sector R_n are given by:

$$\tilde{\pi}_{R_n, k_n} = (p_{R_n} - c)r_{n, k_n} - \delta\gamma_f E = \pi_{R_n, k_n} - \delta\gamma_f E, \quad (2.2)$$

where p_{R_n} is the price in Sector R_n and π_{R_n, k_n} represents firm profits without damage from emissions but inclusive of any taxes imposed by the government for producing emissions.¹⁸

There are two groups, consumer-workers and institutional investors, who own the firms in the economy. The firms in Sector Q and Sector R_n are directly owned by both consumer-workers and institutional investors, the latter owning firms for the benefit of consumer-workers, whilst the firms in Sector Y are directly owned only by consumer-workers. There is a unit mass, $0 \leq j \leq 1$, of consumer-workers, each denoted j , who derive utility from consuming goods q , r_n and y , and disutility from the damage from emissions, given by $\gamma_{cw}E$. A representative consumer j 's utility function is:¹⁹

$$U_j(Q_j, R_{n,j}, y_j) = aQ_j - \frac{Q_j^2}{2} + \sum_n \left(aR_{n,j} - \frac{R_{n,j}^2}{2} \right) + y_j - \delta\gamma_{cw}E. \quad (2.3)$$

Each consumer-worker has L_j units of labor from which they earn a labor income wL_j . As the owners of the firms in Sector Y , consumer-workers receive zero profits. As owners of Sectors Q and R_n , consumer-workers collectively directly own c_Q and c_{R_n} percent of each of Sectors Q and Sector R_n , and are recipients of the remainder through institutional investors to whom they pay a management fee as a percentage of assets of α .²⁰ Therefore, they collectively receive from their direct ownership $c_Q\Pi_Q + \sum_n c_{R_n}\Pi_{R_n}$, where $\Pi_Q = \sum_i \tilde{\pi}_{Q,i}$ and $\Pi_{R_n} = \sum_{k_n} \tilde{\pi}_{R_n, k_n}$, and collectively receive $(1 - \alpha)((1 - c_Q)\Pi_Q + \sum_n (1 - c_{R_n})\Pi_{R_n})$ through institutional investors. These collective costs and benefits, however, are assumed to be spread amongst infinitely many consumer-workers and therefore are approximately equal to zero for any individual consumer-worker. Thus, when making their consumption and labor decisions, consumer-workers budget constraint can be simplified to $wL_j \geq y_j + p_Q Q_j + \sum_n p_{R_n} R_{n,j}$, and, therefore, the inverse demand functions for Sectors Q and R_n are given by:^{21,22}

$$p_Q = a - Q, \quad (2.4)$$

¹⁸See Appendix A.1.2 for working related to these equations.

¹⁹A quasi-linear quadratic utility function that is linear in the numeraire (money), y , and quadratic in all other goods, q and r_n . We have added a term that is linear in damage from emissions. Assuming utility is linear in the numeraire simplifies the analysis by removing wealth effects, the impact of which is discussed in footnote 15. For the impact of the remaining terms, see Section 2.4 discussing results and limitations.

²⁰The distinction between direct and indirect ownership is made for reasons related to choosing the firm objective, on which we elaborate below.

²¹See Appendix A.1.3 for working related to the demand functions.

²²We assume identical demand curves for all sectors, other than Sector Y , for simplicity. Nothing changes qualitatively if we relax this assumption.

$$p_{R_n} = a - R_n, \quad (2.5)$$

where $Q = q_1 + q_2$ and $R_n = r_{n,1} + r_{n,2}$.

We assume there are two institutional investors, $m = 1, 2$, whose utility is only a function of good y^{23} and is therefore given by $U_m(Q_m, R_{n,m}, y_m) = y_m$. The institutional investors collectively manage $(1 - c_Q)\Pi_Q + \sum_n(1 - c_{R_n})\Pi_{R_n}$ of wealth and both charge a percentage fee of the assets they individually manage of α . We assume that each institutional investor individually manages a portfolio of investments in firms in Sector Q and Sector R_n industries such that the total assets under management ('AUM') of institutional investor m , denoted AUM_m , is given by:

$$AUM_m = (1 - c_Q) \sum_i w_{Q,i,m} \tilde{\pi}_{Q,i} + \sum_n (1 - c_{R_n}) \sum_{k_n} w_{R_n,k_n,m} \tilde{\pi}_{R_n,k_n}, \quad (2.6)$$

where $w_{Q,i,m}$ represents the ownership of institutional investor m of firm i in Sector Q which is then scaled by the proportion of direct ownership of Sector Q of consumer-workers so that institutional investor m 's actual direct ownership is $(1 - c_Q)w_{Q,i,m}$. Note $w_{Q,i,m} + w_{Q,i,-m} = 1$ and $w_{R_n,k_n,m} + w_{R_n,k_n,-m} = 1$, because total ownership proportions sum to 1. For example, $(1 - c_Q)w_{Q,i,m} + (1 - c_Q)w_{Q,i,-m} + c_Q = 1$. Finally, we assume that institutional investor ownership within industries is represented by symmetric common ownership. That is $w_{Q,i,m} = w_{Q,-i,-m}$ and $w_{R_n,k_n,m} = w_{R_n,-k_n,-m}$. Thus, institutional investors' budget constraint is given by $\alpha AUM_m \geq y_m$.

Finally, we assume that the firm objective is determined by the institutional investor with the largest ownership share of the firm according to their active ownership objective and, for simplicity, active ownership objectives are the same across institutional investors. In our model, consumer-workers' collective ownership of a firm in a sector is spread amongst infinitely many consumer-workers, so we assume they display rational apathy with respect to corporate governance matters such as determining the firm objective. As a result, only the two institutional investors are involved in the determination of the firm objective. Since we have symmetric common ownership with two owners in our model, one of the institutional investors is pivotal in a majority voting game; that is, $w_{Q,i,m} = w_{Q,-i,-m} > 0.5$ and $w_{R_n,k_n,m} = w_{R_n,-k_n,-m} > 0.5$. Thus, we assume that the pivotal institutional investor selects the firm objective according with their active ownership objective. Furthermore, for simplicity, we assume that institutional investors have identical active ownership objectives. Thus, firm objectives are also identical.

²³We believe such an assumption aligns most directly with maximising portfolio value, which can be seen by substituting the budget constraint of the institutional investors into the utility function. The idea that an institutional investor does not necessarily maximise portfolio value due to agency issues could be an interesting area for further research, but is beyond the scope of our paper focusing on a set of well-known objective functions (see Section 2.2.2 that follows).

E , which is not in the short-term common owner's objective. Therefore, λ_{INTER,R_n} will play no role for the short-term common owner. Finally, note that since the objective, Equation 2.9, is equal to Equation 2.10 divided by the constant $(1 - c_Q)w_{Q,i,m}$, maximizing the objective is equivalent to maximizing Equation 2.10 which we rewrite as:

$$\tilde{\phi}_{STCO} = \pi_{Q,i} + \lambda_{INTRA,Q}\pi_{Q,-i} + \sum_n \lambda_{INTER,R_n}(\pi_{R_n,k_n} + \lambda_{INTRA,R_n}\pi_{R_n,-k_n}). \quad (2.11)$$

Second is long-term common ownership ('LTCO'), where the objective function can be written as:

$$\begin{aligned} \phi_{LTCO} &= (1 - c_Q) \sum_i w_{Q,i,m} \tilde{\pi}_{Q,i} + \sum_n (1 - c_{R_n}) \sum_{k_n} w_{R_n,k_n,m} \tilde{\pi}_{R_n,k_n} & (2.12) \\ &\propto \tilde{\pi}_{Q,i} + \lambda_{INTRA,Q} \tilde{\pi}_{Q,-i} + \sum_n \lambda_{INTER,R_n} (\tilde{\pi}_{R_n,k_n} + \lambda_{INTRA,R_n} \tilde{\pi}_{R_n,-k_n}) \\ &= \pi_{Q,i} + \lambda_{INTRA,Q} \pi_{Q,-i} + \sum_n \lambda_{INTER,R_n} (\pi_{R_n,k_n} + \lambda_{INTRA,R_n} \pi_{R_n,-k_n}) \\ &\quad - \delta \gamma_f E (1 + \lambda_{INTRA,Q} + \sum_n \lambda_{INTER,R_n} (1 + \lambda_{INTRA,R_n})) \\ &= \tilde{\phi}_{STCO} - \delta \gamma_f E (1 + \lambda_{INTRA}) (1 + \sum_n \lambda_{INTER,R_n}) \\ &= \tilde{\phi}_{STCO} - \delta \gamma_f E (1 + \lambda_{INTRA}) (1 + \lambda_{INTER}) \\ &= \tilde{\phi}_{STCO} - \delta \gamma_{CO} E & (2.13) \end{aligned}$$

since $\lambda_{INTRA,Q} = \lambda_{INTRA,R_n} = \lambda_{INTRA}$, and where $\lambda_{INTER} = \sum_n \lambda_{INTER,R_n} > 0$ and $\gamma_{CO} = \gamma_f (1 + \lambda_{INTRA}) (1 + \lambda_{INTER})$.

Here λ_{INTER} reflects the sum total inter-industry incentives of common ownership arising from the emissions-related actions in Sector Q that affect Sectors R_n . Note that in contrast to the short-term common owner, λ_{INTER} will play a role since the long-term common owner considers damage from GHGs to firms in their portfolio. Finally, note that for similar reasons to those given for the short-term common owner, maximising the objective, Equation 2.12, is equivalent to maximising:

$$\tilde{\phi}_{LTCO} = \tilde{\phi}_{STCO} - \delta \gamma_{CO} E. \quad (2.14)$$

We now consider social responsibility and stakeholder theory. Similar to Hart and Zingales (2017),²⁵ the SRI maximizes long-term profits less the damage to others:

$$\phi_{SRI} = \tilde{\pi}_{Q,i} - \beta E((N-1)I - 1)\delta\gamma_f + \delta\gamma_{cw}) = \phi_{STP} - \delta\gamma_{SRI}E, \quad (2.15)$$

where $\gamma_{SRI} = \gamma_f + \beta((N-1)I - 1)\gamma_f + \gamma_{cw}$, γ_f represents the long-term damage to the firm itself, $0 < \beta \leq 1$ reflects the discount to damage to others from GHGs ('SRI discount factor'), γ_{cw} is the damage to consumer-workers and $((N-1)I - 1)\gamma_f$ is the damage to the other firms in Sector Q and Sectors R_n .

Finally, in addition to the firm's long-term profits and the damage to the 'community' (Freeman, Phillips, and Sisodia, 2020),²⁶ the stakeholder-oriented shareholder considers the consumption benefit to consumer-workers:²⁷

$$\begin{aligned} \phi_S &= \tilde{\pi}_{Q,i} + \theta(U_{cw}(Q, R_n, y) - E((NI - 1)\delta\gamma_f + \delta\gamma_{cw})) \\ &= \phi_{STP} + \theta U_{cw}(Q, R_n, y) - \delta\gamma_S E, \end{aligned} \quad (2.16)$$

where $\gamma_S = \gamma_f + \theta((N-1)I - 1)\gamma_f + \gamma_{cw}$, U_{cw} is the utility of consumer-workers from consumption only (so excluding their share of the damage from the GHG emissions externality) and $0 < \theta \leq 1$ reflects the discount to stakeholder interests ('stakeholder discount factor').²⁸

²⁵Mathematically we directly follow Hart and Zingales (2017) in including profits and damage in the objective function. However, conceptually it is not clear that we follow them. There is an alternative view of social responsibility often expressed in the SRI and CSR literature that equates SRI and CSR to stakeholder theory in the sense that other's interests are considered (e.g. Broccardo, Hart, and Zingales, 2020; Dai and Qiu, 2020). But CSR is not stakeholder theory Freeman and Dmytriiev (2017). CSR and SRI (and ESG for that matter) are concerned with the pursuit of broad social issues (e.g. Freeman and Dmytriiev, 2017; Gillan, Koch, and Starks, 2021; Renneboog, Ter Horst, and Zhang, 2008). We follow this latter definition of SRI, CSR and ESG and consider those objectives where stakeholder interests are considered in total, so including but also beyond how the stakeholders may be affected by the social issues that are the focus of SRIs, as being a more accurate mathematical representation of stakeholder theory.

²⁶We assume the 'community' is represented by Sector Y , Sectors R_n , the other firm in Sector Q and consumer-workers, so the damage term for the stakeholder value maximizer consists of precisely the same damage terms as considered by the SRI.

²⁷The closest to this in the economics literature Magill, Quinzii, and Rochet (2015)

²⁸We acknowledge that stakeholder value maximization may go beyond consumption benefits and the damage from emissions.

2.2.3 The benchmark model

In the benchmark model, we assume firms in Sector Q aim to maximize short-term profits by choosing quantities only. That is, each firm simultaneously chooses quantities, q_i , to maximize their objective:

$$\phi_{STP} = \pi_{Q,i} = (p_Q - c - t)q_i = (a - q_i - q_{-i} - c - t)q_i. \quad (2.7)$$

Emissions, e_i , is then an outcome that is a by-product of the choice of q_i only. This is because the level of emissions is $q_i = e_i$ with appropriate units for emissions (see Section 2.2.1).

Given the model set-up, the Cournot-Nash equilibrium firm-level quantity for each firm in the benchmark model, $q_{i,BM}^*$, is given by:²⁹

$$q_{i,BM}^* = \frac{a - c - t}{3}, \quad (2.17)$$

which is the conventional Cournot-Nash equilibrium quantity in duopoly adjusted for the tax for emissions associated with production. The level of emissions in the benchmark model, $e_{i,BM}^*$, is also given by:

$$e_{i,BM}^* = \frac{a - c - t}{3} \quad (2.18)$$

since in the model units of emissions are chosen such that $q_i = e_i$.

2.2.4 Comparison of the results from the alternative models to the results of the benchmark model

In this section, we present results comparing the benchmark model and the set of alternative models. Each model in the set of alternative models corresponds to institutional investors having one of the active ownership objectives in Section 2.2.2, and therefore firms having the same firm objectives, other than short-term profit maximization. We split our results in two. In the first set of results, we present comparisons of all active ownership objectives, except the alternative model with stakeholder-oriented shareholders, to the benchmark model. In the second set, we focus on results related to the stakeholder-oriented shareholder. Further note that in our results we do not assume a common time discount factor, δ , across those active ownership objectives in which δ appears and likewise for the intra-industry incentive, λ_{INTRA} unless otherwise specified.

²⁹See Appendix A.2.1 for working.

2.2.4.1 Active ownership objectives other than stakeholder

The results for quantities and emissions (since they are equal) for all active ownership objectives except stakeholder-oriented shareholders are given by:³⁰

$$q_{i,\phi}^* = e_{i,\phi}^* = \frac{a - c - t - \delta\gamma_\phi}{3 + \xi_\phi}, \quad (2.19)$$

where ϕ signifies the active ownership objective, and $\delta\gamma_\phi$ and ξ_ϕ differ by active ownership objective. Specifically, $\delta\gamma_\phi = \delta\gamma_f$ and $\xi_\phi = 0$ for the long-term profit maximizer, $\delta\gamma_\phi = 0$ and $\xi_\phi = \lambda_{INTRA}$ for the short-term common owner, $\delta\gamma_\phi = \delta\gamma_{CO}$ and $\xi_\phi = \lambda_{INTRA}$ for the long-term common owner, and $\delta\gamma_\phi = \delta\gamma_{SRI}$ and $\xi_\phi = 0$ for the SRI.

Since for the short-term profit maximizer $\delta\gamma_\phi = 0$ and $\xi_\phi = 0$, all the above active ownership types reduce quantities and emissions relative to the short-term profit maximizer; the numerator decreases or the denominator increases.

Proposition 1. *Quantities and emissions relative to the benchmark model (that is, the short-term profit maximizer) are:*

- i. *Lower for the long-term profit maximizer for all time discount factors $0 < \delta \leq 1$;*
- ii. *Lower for the short-term common owner for all intra-industry incentives $0 < \lambda_{INTRA} < 1$;*
- iii. *Lower for the long-term common owner for all time discount factors $0 < \delta \leq 1$, intra-industry incentives $0 < \lambda_{INTRA} < 1$ and inter-industry incentives $\lambda_{INTER} > 0$; and*
- iv. *Lower for the SRI for all time discount factors $0 < \delta \leq 1$ and SRI discount factors $0 < \beta \leq 1$.*

The incentives driving these results can be sorted into three categories: the long-term incentive from damage to the firm, the incentive arising from damage to other agents in the model, and the intra-industry common ownership incentive. The long-term incentive relates to future damage to the firm. This drives the reduction in emissions relative to the short-term profit maximizer for all except the short-term common owner. There is then the incentive due to damage to other agents in the model, which influences the long-term common owner and SRI; the long-term common considers other firms in their portfolio and for the SRI considers the damage to all agents. Finally, both the short-term and long-term common owners are driven by the intra-industry common ownership incentive. In the case of the short-term common owner, the intra-industry common ownership incentive is the only incentive driving the result.

³⁰See Appendices A.2.2 to A.2.5 for working.

2.2.4.2 Stakeholder-oriented shareholders

Quantities and emissions for the stakeholder-oriented shareholder are given by:³¹

$$q_{i,S}^* = e_{i,S}^* = \frac{a - c - t - \delta\gamma_S}{3 - 2\theta}. \quad (2.20)$$

From the above equation it can be seen that quantities and emissions relative to the short-term profit maximizer are ambiguous; the numerator decreases, but the denominator decreases too.

Proposition 2. *Quantities and emissions relative to the benchmark model (that is, the short-term profit maximizer) are:*

i. *Lower for the stakeholder-oriented shareholder for all $0 < \theta \leq 1$ when $Q_{BM}^* - \delta(\gamma - \gamma_f) < 0$; and*

ii. *Lower [higher] for the stakeholder-oriented shareholder if and only if the stakeholder discount factor $\theta < \theta^*(\delta)$ [$\theta > \theta^*(\delta)$] when $Q_{BM}^* - \delta(\gamma - \gamma_f) > 0$.*

where $\theta^*(\delta) = \frac{\delta\gamma_f}{Q_{BM}^* - \delta(\gamma - \gamma_f)}$ and $Q_{BM}^* = 2q_{BM}^*$

Unlike the results for other active owners in Section 2.2.4.1, the stakeholder-oriented shareholder does not necessarily reduce quantities and emissions. The different result is driven by stakeholder-oriented shareholders having an incentive to expand production as they consider the consumption benefit for consumer-workers. In contrast, all other active ownership objectives only include incentives to reduce production. Since the stakeholder-oriented shareholder's incentive to expand production is moderated by θ , and their incentives to reduce production are moderated by δ and θ , the net incentive depends on δ and θ .

Separating the incentives into those terms associated with θ and those associated with δ only, $\theta^*(\delta)$ essentially becomes the ratio of marginal damage to the firm from expanding production to the net marginal benefit of production (so consumption minus damage) to stakeholders other than the firm. That is:

$$\theta^*(\delta) = \frac{\delta\gamma_f}{Q_{BM}^* - \delta(\gamma - \gamma_f)}. \quad (2.21)$$

From this equation it can be seen that if the consumption benefit is less than the damage to stakeholders other than the firm, as represented by $Q_{BM}^* - \delta(\gamma - \gamma_f) < 0$ and corresponding to Proposition 2.i., $\theta^*(\delta)$ is negative. Thus, $\theta > \theta^*(\delta)$ holds for any $0 < \theta \leq 1$.

But if the consumption benefit is greater than the damage to stakeholders other than the firm, then the damage to the firm must be traded off against the net benefit to stakeholders other than the firm in order to determine whether to reduce quantities and emissions. Despite this ambiguity, conditions under which any stakeholder-oriented shareholder will reduce quanti-

³¹See Appendix A.2.6 for working.

ties when $Q_{BM}^* - \delta(\gamma - \gamma_f) > 0$ can be derived.³² The derivation follows from finding industry characteristics such that $\theta^*(\delta) > 1$, which means $\theta < \theta^*(\delta)$ holds for any $0 < \theta \leq 1$. The exercise effectively ensures that the damage from emissions to all stakeholders is larger than the consumption benefit as assessed by any stakeholder-oriented shareholder (so with any θ).

Thus, there is a set of industry characteristics for which any stakeholder-oriented shareholder will reduce quantities and emissions relative to the short-term profit maximizer. Combining this result with that of Proposition 1 leads to the following corollary relating all active ownership objectives to the benchmark model, where δ_S is the time discount factor corresponding to the stakeholder-oriented shareholder.

Corollary 1 (The active ownership identification problem in the context of GHG emissions). *If $Q_{BM}^* \leq \delta_S \gamma$, quantities and emissions relative to the benchmark model are lower for all active ownership objectives for all time discount factors $0 < \delta \leq 1$, intra-industry incentives $0 < \lambda_{INTRA} < 1$, inter-industry incentives $\lambda_{INTER} > 0$, SRI discount factors $0 < \beta \leq 1$, and stakeholder discount factors $0 < \theta \leq 1$.*

³²It should be noted that there are no conditions under which all stakeholder-oriented shareholders would increase quantities and emissions. Intuitively, there is always some θ close enough to zero that ensures that the net benefit to stakeholders other than the firm discounted by θ is less than the damage to the firm, so it is always possible that some stakeholder-oriented shareholder decides to decrease quantities, whilst others decide to increase quantities.

2.3 A solution to the active ownership identification problem in the context of GHG emissions

In the previous section, we demonstrated the active ownership identification problem where GHG emissions were an inseparable negative externality. GHG emissions, however, are no longer inseparable externalities; firms can invest in mitigation, which reduces and, in some cases, separates GHG emissions from production. Firms can also invest in adaptation to reduce the damage to the firm.³³

Indeed, two of the papers listed in Section 2.2 investigating firm-level GHG emissions and institutional investor influence also investigate the effects of institutional investors on investments in mitigation; Akey and Appel (2019) and Naaraayanan, Sachdeva, and Sharma (2020).³⁴ In their sample of hedge funds, Akey and Appel (2019) find no association between hedge fund activism and investments in mitigation. In their sample from the Boardroom Accountability Project ('BAP'), Naaraayanan, Sachdeva, and Sharma (2020) find a positive association between BAP environmental activism and investments in mitigation. Similar to Section 2.2, our question in this section is: with this information, what can we conclude about the active ownership type of the hedge funds and the BAP?

To answer this question, we consider models in which firms can invest in mitigation, m_i , to reduce their net emission is given by $q_i - m_i$, and invest in adaptation, a_i , to reduce the damage to the firm, $\gamma_f(E - a_i)$, simultaneous with their choice of quantities. To make our arguments we compared alternative models to a benchmark model like the one in Section 2.2, but updated the benchmark model to allow firms to invest in mitigation and adaptation. We refer to this benchmark model as the benchmark mitigation-adaptation model, *BMAM*. We first model the general case, showing that the short-term common owner can be differentiated from other active ownership objectives by no change in investments in mitigation or adaptation relative to the short-term profit maximizer, whilst other active ownership objectives all generate a positive change. This result suggests that the hedge funds in Akey and Appel (2019) may be short-term common owners, whilst those institutional investors associated with the BAP from Naaraayanan, Sachdeva, and Sharma (2020) are not short-term common owners. But the result does not necessarily suggest that those institutional investors associated with the BAP from Naaraayanan, Sachdeva, and Sharma (2020) can definitely be considered long-term shareholders and/or stakeholder-oriented shareholders, nor are they definitely not long-term

³³For simplicity, we do not allow offsetting in our model. This is possibly an area for future research.

³⁴Akey and Appel (2019) and Naaraayanan, Sachdeva, and Sharma (2020) refer to mitigation as abatement in their papers.

common owners or SRIs.^{35,36}

To resolve the remaining ambiguity, we then focus on two further industry conditions. The first is when there is no exposure to damage to climate change for firms in Sector Q . In this situation, we find that the long-term profit maximizer will not increase mitigation or reduce quantities whilst other active ownership types will. The second is when there is high willingness to pay in Sector Q and revenue varies non-monotonically with quantities.³⁷ In this case, the long-term common owner and SRI can be separated based on their impacts on revenue.

2.3.1 Mitigation and adaptation

2.3.1.1 The benchmark mitigation-adaptation model

Again, we focus on Sector Q since it is the sector producing emissions. Compared to Section 2.2.3, we now assume firms in Sector Q aim to maximize short-term profits by choosing mitigation and adaptation as well as quantities. That is, firms simultaneously choose mitigation, m_i , adaptation, a_i , and quantities, q_i , to maximize the following objective:

$$\phi_{STP} = \pi_{Q,i} = (p_Q - c - t)q_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2}, \quad (2.22)$$

where ρ and ν capture the rate of change of the marginal cost of mitigation and adaptation. It is assumed that units of mitigation in terms of emissions are chosen such that, i.e. $e_i = q_i - m_i$. Furthermore, it is also assumed that one unit of adaptation directly offsets γ_f units of damage, i.e. $\gamma_f(E - a_i)$.³⁸ For simplicity, we model the choices of mitigation, adaptation and quantity as separable, which will result in equilibrium choices of mitigation, adaptation and quantity being independent of each other. Thus the equilibrium quantities are identical to Equation 2.17 in Section 2.2.3.

³⁵It should be noted that Naaraayanan, Sachdeva, and Sharma (2020) do find a statistically insignificant negative correlation between BAP environmental activism and production. One might be tempted to interpret the statistical insignificance as indicating a low magnitude change in the negative direction, which might suggest the results most support those institutional investors associated with the BAP being either long-term profit maximizers or perhaps even stakeholder-oriented (the latter if this is considered not strong enough evidence to show a reduction, so they could be increasing production). We instead interpret the statistical insignificance as not providing sufficient evidence to resolve the issue, whilst still being consistent with our model.

³⁶To be consistent with our treatment of the results from Naaraayanan et al. (2020) in the previous footnote, we also note that whilst Akey and Appel (2019) find no statistically significant correlation between hedge fund activism and mitigation, the correlation is negative. Our modelling does not predict any negative correlations relative to the short-term profit maximizer in the benchmark model. This suggests that the assuming the short-term profit maximizer as the benchmark might be incorrect in the sample of Akey and Appel (2019). Resolving this issue is an area for future research which we discuss in the Discussion and Limitations section.

³⁷A condition that holds for all demand curves that intersect both the price and quantity axes

³⁸Although, in the case of the short-term profit maximizer, the benefits of adaptation are not considered since the short-term profit maximizer does not consider the damage from emissions in their objective and there is no tax incentivizing adaptation.

Given the model set-up, the equilibrium levels of mitigation, $m_{i,BMAM}^*$, and adaptation, $a_{i,BMAM}^*$, are given by:³⁹

$$m_{i,BMAM}^* = \frac{t}{\rho}, \quad (2.23)$$

$$a_{i,BMAM}^* = 0. \quad (2.24)$$

Note that whilst the short-term profit maximizer does not consider the future damage from climate change, it does some mitigation because of the tax on emissions. In contrast, there is no tax incentive to adapt, so the short-term profit maximizer does not invest in adaptation.

Since $e_i = q_i - m_i$, the equilibrium level of emissions in the benchmark mitigation-adaptation model will be different to the benchmark model, and is given by:

$$e_{i,BMAM}^* = q_{i,BMAM}^* - m_{i,BMAM}^* = \frac{a - c - t}{3} - \frac{t}{\rho}. \quad (2.25)$$

2.3.1.2 Comparison of the alternative mitigation-adaptation models and the benchmark mitigation-adaptation model

In this section, we first present the results associated with mitigation and adaptation, then the results for emissions for the stakeholder-oriented shareholder only. The results for quantities for all active ownership objectives and for emissions for all active ownership objectives other than the stakeholder-oriented shareholder are identical to Propositions 1 and 2 in Section 2.2.4. The results for quantities are identical since we model choices of mitigation, adaptation and quantities as separable. Whilst emissions now includes mitigation, it will be shown below that mitigation either does not change or increases relative to the benchmark. Since mitigation is negatively related to emissions, recall $e_i = q_i - m_i$, the changes in quantities and mitigation relative to the benchmark mitigation-adaptation model mean that the direction of the changes in emissions relative to the benchmark mitigation-adaptation model are the same as Proposition 1 in Section 2.2.4. However, the conditions for the stakeholder-oriented shareholder are different to Proposition 2 in the case of emissions, so we also present the emissions-related results for stakeholder-oriented shareholders. We present the mitigation and adaptation results for the stakeholder-oriented shareholder along with the other active ownership objectives.

³⁹See Appendix A.3.1 for working for the benchmark mitigation-adaptation model.

2.3.1.2.1 Mitigation and adaptation for all active ownership objectives

The results for mitigation and adaptation for all active ownership objectives is summarized by:⁴⁰

$$m_{i,\phi}^* = \frac{t + \delta\gamma_{\phi,m}}{\rho}, \quad (2.26)$$

$$a_{i,\phi}^* = \frac{\delta\gamma_{\phi,a}}{\nu}, \quad (2.27)$$

where ϕ signifies the active ownership objective, m signifies mitigation and a signifies adaptation so that $\gamma_{\phi,m}$ and $\gamma_{\phi,a}$ differ by active ownership objective and between mitigation and adaptation. Specifically, $\delta\gamma_{\phi,m} = \delta\gamma_f$ and $\delta\gamma_{\phi,a} = \delta\gamma_f$ for the long-term profit maximizer, $\delta\gamma_{\phi,m} = 0$ and $\delta\gamma_{\phi,a} = 0$ for the short-term common owner, $\delta\gamma_{\phi,m} = \delta\gamma_{CO}$ and $\delta\gamma_{\phi,a} = \delta\gamma_f$ for the long-term common owner, $\delta\gamma_{\phi,m} = \delta\gamma_{SRI}$ and $\delta\gamma_{\phi,a} = \delta\gamma_f$ for the SRI, and $\delta\gamma_{\phi,m} = \delta\gamma_S$ and $\delta\gamma_{\phi,a} = \delta\gamma_f$ for the stakeholder-oriented shareholder.

Since for the short-term profit maximizer $\delta\gamma_{\phi,m} = 0$ and $\delta\gamma_{\phi,a} = 0$, all of the above active ownership types increase mitigation and adaptation relative to the short-term profit maximizer except the short-term common owner. The short-term common owner's investments in mitigation and adaptation are identical to the short-term profit maximizer's.

Proposition 3. *Mitigation and adaptation relative to the benchmark mitigation-adaptation model (that is, the short-term profit maximizer) are:*

- i. *Higher for the long-term profit maximizer for all time discount factors $0 < \delta \leq 1$;*
- ii. *Identical for the short-term common owner for all intra-industry incentives $0 < \lambda_{INTRA} < 1$;*
- iii. *Higher for the long-term common owner for all time discount factors $0 < \delta \leq 1$, intra-industry incentives $0 < \lambda_{INTRA} < 1$ and inter-industry incentives $\lambda_{INTER} > 0$; and*
- iv. *Higher for the SRI for all time discount factors $0 < \delta \leq 1$ and SRI discount factors $0 < \beta \leq 1$.*
- v. *Higher for the stakeholder-oriented shareholder for all time discount factors $0 < \delta \leq 1$ and stakeholder discount factors $0 < \theta \leq 1$.*

These results can be explained using two of the incentives from Section 2.2.4; the long-term incentive from damage to the firm and the incentive arising from damage to other agents in the model. As the long-term incentive relates to future damage to the firm, those active owners with the long-term incentive (i.e. all active owner types except the short-term common owner) will reduce damage by investing in mitigation and reduce exposure to damage by investing in adaptation relative to the short-term profit maximizer. Those with the incentives arising from damage to other agents in the model (i.e., the SRI, long-term common owner, and stakeholder-

⁴⁰See Appendices A.3.2 to A.3.6 for the related working.

oriented shareholder) will further invest in mitigation to reduce damage to the other agents. Finally, since the short-term common owner does not have either of those incentives, they do not mitigate or adapt beyond the amount encouraged by the tax incentives like the short-term profit maximizer.

2.3.1.2.2 Emissions for stakeholder-oriented shareholders

For the stakeholder-oriented shareholder, emissions is given by:

$$e_{i,S}^* = q_{i,S}^* - m_{i,S}^* = \frac{a - c - t - \delta\gamma_S}{3 - 2\theta} - \frac{t + \delta\gamma_S}{\rho}. \quad (2.28)$$

Whilst mitigation increases relative to the short-term profit maximizer, the quantities for the stakeholder-oriented shareholder relative to the short-term profit maximizer continue to be ambiguous. Thus, emissions is also ambiguous.⁴¹

Proposition 4. *Emissions relative to the benchmark mitigation-adaptation model (that is, the short-term profit maximizer) are lower for the stakeholder-oriented shareholder if and only if the following holds:*

$$\frac{\theta(Q_{BMAM}^* - \delta(\gamma - \gamma_f)) - \delta\gamma_f}{3 - 2\theta} < \frac{\delta\gamma_S}{\rho},$$

where $\gamma_S = \gamma_f + \theta(\gamma - \gamma_f)$ and $Q_{BMAM}^* = 2q_{BMAM}^*$

Compared to Proposition 2, the introduction of mitigation adds further complexity to the conditions determining the relative movements. To see this note that for a reduction in emissions to occur the following must hold.

$$q_i^* - q_{i,BMAM}^* = \frac{\theta(Q_{BMAM}^* - \delta(\gamma - \gamma_f)) - \delta\gamma_f}{3 - 2\theta} < \frac{\delta\gamma_S}{\rho} = m_i^* - m_{i,BMAM}^*. \quad (2.29)$$

Since $m_i^* - m_{i,BMAM}^* > 0$ from Proposition 3, the condition in Proposition 4 is always satisfied if $q_i^* - q_{i,BMAM}^* < 0$. Thus, using the results from Section 2.2.4.1, Corollary 1 can be expanded to include mitigation.⁴²

Corollary 2 (The active ownership identification problem in the context of GHG emissions when firms can mitigate emissions). *If $Q_{BMAM}^* \leq \delta_S\gamma$, quantities and emissions relative to the benchmark model are lower for all active ownership objectives for all time discount factors $0 < \delta \leq 1$, intra-industry incentives $0 < \lambda_{INTRA} < 1$, inter-industry incentives $\lambda_{INTER} > 0$, SRI discount factors $0 < \beta \leq 1$, and stakeholder discount factors $0 < \theta \leq 1$.*

⁴¹See Appendix A.3.6.2 for the related working

⁴²For the same reasons as in footnote 32, there are no conditions under which all stakeholder-oriented shareholders increase quantities and emissions.

2.3.2 Zero exposure to damage

Thus far we have been able to clearly separate the short-term profit maximizer and short-term common owner from the rest, and provide a somewhat fuzzy separation for the stakeholder-oriented shareholder.⁴³ In this section, we take advantage of the long-term incentive from damage to the firm to suggest a situation in which the long-term shareholder can also be separated. Doing so also introduces cleaner separation conditions for the stakeholder-oriented shareholder. To do so, we analyse the situation when the firm's exposure to damage is zero.⁴⁴ To show this, we now assume that firms in Sector Q and Sectors R_n have different exposures to damage, given by γ_Q and γ_{R_n} , and that $\gamma_Q \approx 0$ and $\gamma_{R_n} = \gamma_f$. Since there is no exposure to damage for firms in in Sector Q , we do not consider results related to adaptation in the sections that follow. Finally, we note that the set-up and results for mitigation, adaptation and emissions are identical to Equations 2.23, 2.24 and 2.25, respectively, in Section 2.3.1.1.

We first focus on the results for mitigation and then the results for quantities and emissions. For mitigation, we follow a similar structure to Section 2.3.1.2 by presenting results for all active ownership objectives together. For quantities and emissions, we follow a similar structure to Section 2.2.4 by presenting two sets of results due to the complexity of the results for the stakeholder-oriented shareholder.

2.3.2.1 Mitigation

The expression for equilibrium mitigation is the same as Equation 2.26, however now $\delta\gamma_f = 0$ for all active owner types. Thus, the results for mitigation for all active ownership objectives can be summarized by the following proposition.

Proposition 5. *If the firm is not exposed to damage, then mitigation relative to the benchmark mitigation-adaptation model (that is, the short-term profit maximizer) are:*

- i. *Identical for the long-term profit maximizer for all time discount factors $0 < \delta \leq 1$;*
- ii. *Identical for the short-term common owner for all intra-industry incentives $0 < \lambda_{INTRA} < 1$;*
- iii. *Higher for the long-term common owner for all time discount factors $0 < \delta \leq 1$, intra-industry incentives $0 < \lambda_{INTRA} < 1$ and inter-industry incentives $\lambda_{INTER} > 0$; and*

⁴³This somewhat fuzzy separation is reflected in footnotes 32 and 42. Some stakeholder-oriented shareholders, but not all, may increase quantities and emissions.

⁴⁴Whilst at first glance such conditions may seem counterintuitive, there are some industries and firms that not only have zero exposure but could benefit from climate change. That is, $\gamma_Q < 0$. For example, it is predicted that climate change will lead to increased energy demand (e.g. Ruijven, De Cian, and Sue Wing, 2019), leading to higher firm-level profits all else equal. Furthermore, it could be argued that whilst perhaps $\gamma_Q \neq 0$, for some firms $\gamma_f e_i \approx 0$ if γ_f and e_i are assumed to be sufficiently small, whilst $\gamma e_i > 0$; these conditions reflect the notion that a firm's emissions barely impact its own profits, but cause non-zero damage in total. Under such conditions, the results from this section remain.

- iv. Higher for the SRI for all time discount factors $0 < \delta \leq 1$ and SRI discount factors $0 < \beta \leq 1$.
- v. Higher for the stakeholder-oriented shareholder for all time discount factors $0 < \delta \leq 1$ and stakeholder discount factors $0 < \theta \leq 1$.

Compared to Proposition 3, it can now be seen that the long-term profit maximizer does not increase mitigation relative to the short-term profit maximizer. For the remaining active ownership objectives, the results in Proposition 5 are identical to those in Proposition 3.

These results are driven by whether an incentive to mitigate arises from considering damage to other agents in the model. As noted above, the long-term incentive arising from damage to the firm has been removed by assuming exposure to damage is zero. Thus, the long-term profit maximizer has no incentive beyond the tax incentive to invest in mitigation like the short-term profit maximizer and the short-term common owner. The long-term common owner, SRI and stakeholder-oriented shareholder, however, all have incentives to mitigate arising from damage to other agents in the model; the long-term common owner to reduce damage to their investments in other sectors, the SRI and the stakeholder-oriented shareholder to reduce damage to all other agents.

2.3.2.2 Quantities and emissions of all active ownership objectives except stakeholder

The expression for equilibrium quantities is the same as Equation 2.19, however now $\delta\gamma_f = 0$ for all active owner types. Thus, results for quantities and emissions for all active ownership objectives except stakeholder-oriented shareholders can be summarized by the following proposition.

Proposition 6. *If the firm is not exposed to damage, quantities and emissions relative to the benchmark model (that is, the short-term profit maximizer) are:*

- i. *Identical for the long-term profit maximizer for all time discount factors $0 < \delta \leq 1$;*
- ii. *Lower for the short-term common owner for all intra-industry incentives $0 < \lambda_{INTRA} < 1$;*
- iii. *Lower for the long-term common owner for all time discount factors $0 < \delta \leq 1$, intra-industry incentives $0 < \lambda_{INTRA} < 1$ and inter-industry incentives $\lambda_{INTER} > 0$; and*
- iv. *Lower for the SRI for all time discount factors $0 < \delta \leq 1$ and SRI discount factors $0 < \beta \leq 1$.*

In contrast to Proposition 1, the long-term profit maximizer now sets quantities and emissions identical to the short-term profit maximizer. The results for other active ownership objectives are identical to Proposition 1. Since the long-term incentive arising from damage to the firm has been removed, the long-term profit maximizer has no incentive to reduce quantities or increase mitigation relative to the short-term profit maximizer. Since $e_i = q_i - m_i$, the long-

term profit maximizer therefore also does not reduce emissions relative to the short-term profit maximizer. Those with the other active ownership objectives either have the intra-industry common ownership incentive, which incentivizes a reduction in quantities, or the incentive arising from damage to agents other than the firm in the model, which incentivizes both a reduction in quantities and increase in mitigation. Thus, the other active ownership objectives will reduce quantities and emissions relative to the short-term profit maximizer.

2.3.2.3 Quantities and emissions of stakeholder-oriented shareholders

The expression for equilibrium quantities for the stakeholder-oriented shareholder is the same as Equation 2.20. However, now $\delta\gamma_f = 0$. The results for quantities for stakeholder-oriented shareholders are summarized by the following proposition.

Proposition 7. *If the firm is not exposed to damage, then quantities relative to the benchmark mitigation-adaptation model (that is, the short-term profit maximizer) are lower [higher] for the stakeholder-oriented shareholder for all $0 < \theta \leq 1$ when [the converse of] $Q_{BM}^* < \delta\gamma$ holds where $Q_{BM}^* = 2q_{i,BM}^*$.*

Again, in contrast to the other active ownership objectives and similar to Proposition 2, the stakeholder-oriented shareholder does not necessarily reduce quantities relative to the short-term profit maximizer. However, in contrast to footnotes 32 and 42, by Proposition 7 there are now conditions under which the stakeholder-oriented shareholder unambiguously increases quantities. Since the firm is no longer exposed to damage, the stakeholder-oriented shareholder is no longer trading off the damage to the firm against the net benefit to stakeholders other than the firm. Thus, stakeholder-oriented shareholder's decision to expand or reduce production is entirely based on whether the net benefit to stakeholders other than the firm, $Q_{BM}^* - \delta\gamma$,⁴⁵ is greater or less than zero.

The expression for equilibrium emissions for the stakeholder-oriented shareholder is the same as Equation 2.28. However, now $\delta\gamma_f = 0$. The results for emissions for stakeholder-oriented shareholders are summarized by the following proposition.⁴⁶

Proposition 8. *If the firm is not exposed to damage, then emissions relative to the benchmark mitigation-adaptation model (that is, the short-term profit maximizer) are lower [higher] for the stakeholder-oriented shareholder if and only if [the converse of] $\theta < \theta^*(\delta)$ holds, which is true for all $0 < \theta \leq 1$ when $Q_{BM}^* - \delta\gamma < \frac{\delta\gamma}{\rho}$ [$Q_{BMAM}^* - \delta\gamma > 3\frac{\delta\gamma}{\rho}$] where $\theta^*(\delta) = \frac{3}{2} - \frac{Q_{BMAM}^* - \delta\gamma}{2\frac{\delta\gamma}{\rho}}$.*

⁴⁵The expression is identical to that in Proposition 2, except now $\gamma_Q = 0$ so that $\gamma = \gamma - \gamma_Q$.

⁴⁶See Appendix A.3.6.3 for working.

The explanation for Proposition 8 is similar to Proposition 4, however, now $\gamma_Q \approx 0$. Substituting $\gamma_Q = 0$ into the condition from Proposition 4 yields:

$$q_i^* - q_{i,BMAM}^* = \frac{\theta(Q_{BMAM}^* - \delta\gamma)}{3 - 2\theta} < \theta \frac{\delta\gamma}{\rho} = m_i^* - m_{i,BMAM}^*. \quad (2.30)$$

Thus, the stakeholder-oriented shareholder reduces emissions if the incentive to mitigate is larger than the incentive to expand production, and vice versa. Also, by again noting $0 < \theta \leq 1$, conditions under which all stakeholder-oriented shareholders will either increase or decrease emissions can be derived.

These results mean that Corollary 2 can be expanded to include the case where firms are not exposed to damage from GHG emissions, but changed to account for the differing results for the long-term profit maximizer.

Corollary 3 (The active ownership identification problem in the context of GHG emissions when firms can mitigate emissions and firms are not exposed to damage). *When firms can invest in mitigation to reduce emissions, if $Q_{BMAM}^* \leq \delta_S\gamma$ and the firm is not exposed to damage from GHG emissions, quantities and emissions relative to the benchmark model are lower for all active ownership objectives, except the long-term profit maximizer, for all time discount factors $0 < \delta \leq 1$, intra-industry incentives $0 < \lambda_{INTRA} < 1$, inter-industry incentives $\lambda_{INTER} > 0$, SRI discount factors $0 < \beta \leq 1$, and stakeholder discount factors $0 < \theta \leq 1$.*

In contrast to Corollaries 1,2, and 6, however, there are conditions under which all stakeholder-oriented shareholders will increase quantities and emissions when the firm is not exposed to damage from GHG emissions.

Corollary 4. *When firms can invest in mitigation to reduce emissions, if $Q_{BMAM}^* - \delta_S\gamma > 3\frac{\delta_S\gamma}{\rho}$ and the firm is not exposed to damage from GHG emissions, quantities and emissions relative to the benchmark model are higher for stakeholder-oriented shareholders for all stakeholder discount factors $0 < \theta \leq 1$.*

2.3.3 High willingness to pay and non-monotone revenue

We now separate the long-term common owner from the SRI as these are the only remaining active ownership objectives for which separation conditions have not been derived. However, to do so we require either a new measure from the model or a model in which inputs are not priced competitively. In this section we cover the former and in the next section we cover the latter. We require a new measure from the model as both the long-term common owner and SRI move the firm in identical directions in terms of quantities, emissions, investments in mitigation and investments in adaptation. Therefore, these measures cannot be directly used to produce a separation.

To produce a separation, we focus on revenue. We do so for two reasons, one pragmatic and one technical. The pragmatic reason is that revenue is a widely available measure and is therefore available for empirical work. Furthermore, our model can be considered a relatively accurate representation for revenue, whereas other measures available from our model and empirically, such as profit, might reasonably be significantly affected by many factors not in our model.⁴⁷

The technical reason is that in some circumstances revenue is not a monotone function of quantities.⁴⁸ Thus, whilst quantities for the long-term common owner and SRI are always lower than the short-term profit maximizer, the same does not apply for revenue; it is possible for a reduction in quantities⁴⁹ to produce either an increase or decrease in revenue.⁵⁰ We illustrate this graphically in Figure 2.1 below. If willingness to pay, represented by a in our model, is low, then equilibrium quantities are to the left of the revenue maximization point as indicated by the yellow circle in Figure 2.1a. As a result, a reduction in quantities always results in a decrease in revenue. But if willingness to pay is high, then equilibrium quantities for the short-term profit maximizer are to the right of the revenue maximization point as indicated by the orange circle in Figure 2.1b. In this case, a reduction in quantities can produce either an increase or decrease in revenue, depending on the magnitude of the change in quantities. Therefore, when willingness to pay is high, the effect of decreasing quantities on revenue is somewhat ambiguous.

We exploit this property of the revenue function when willingness to pay is high to separate the long-term common owner from the SRI under the additional requirement that inter-industry common ownership is high.⁵¹ Here it is important to note that we now put a subscript on δ to

⁴⁷Nonetheless, one could, qualitatively speaking, replicate the results based on revenue below for other non-monotonic functions of choice variables since the key factor driving the result is non-monotonicity.

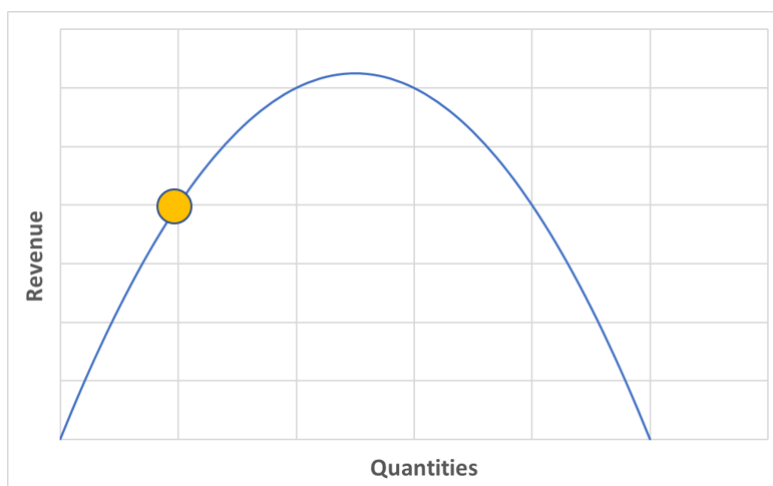
⁴⁸It is important to note, however, that such an assumption is not satisfied by CES utility functions.

⁴⁹We focus on a reduction in quantities because a reduction in quantities occurs for each active owner type compared to the benchmark models under our model and assumptions.

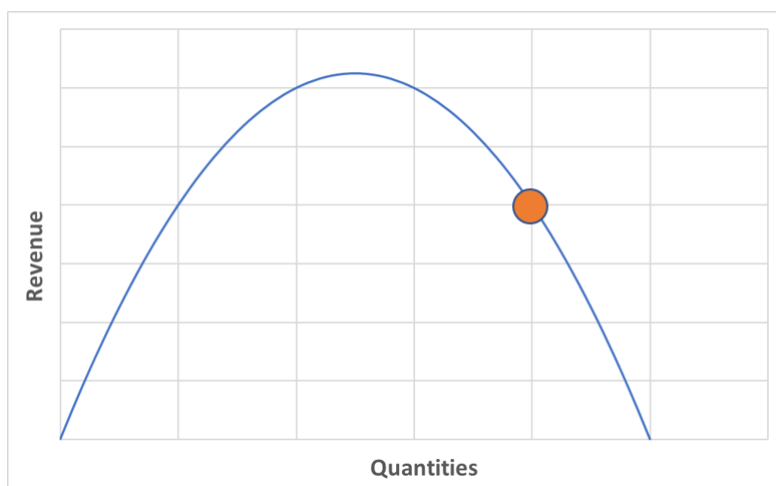
⁵⁰See Appendix A.3.7.1 and A.3.7.2 for working related to this point

⁵¹See Appendices A.3.7.3 to A.3.7.11 for working related to this point.

Figure 2.1: Revenue and the location of the benchmark model quantities based on willingness to pay. Note that the revenue curves depend on willingness to pay so are not the same between the panels



(a) The position of equilibrium benchmark model quantity on the revenue curve when willingness to pay is low



(b) The position of equilibrium benchmark model quantity on the revenue curve when willingness to pay is high

indicate the active ownership objective to which δ belongs. That is:⁵²

Proposition 9. *If $a \geq 4(c + t) + 2\delta_{SRI}\gamma$ and $\lambda_{INTER} \geq \frac{\delta_{SRI}}{\delta_{CO}} \frac{\gamma}{\gamma_f} - 1$, then revenue relative to the benchmark mitigation-adaptation model (that is, the short-term profit maximizer) is:*

- i Lower for the long-term common owner for all intra-industry common ownership incentives $0 < \lambda_{INTRA} < 1$; and*
- ii. Higher for the SRI for all SRI discount factors $0 < \beta \leq 1$.*

The intuition behind Proposition 9 is that both active owner types have an incentive to reduce quantities due to the damage from GHG emissions to agents other than the firm. However, the SRI's incentive is capped ($\beta \leq 1$) whilst the long-term common owner's incentive is not capped ($\lambda_{INTER} > 0$). Thus, one can find conditions under which the incentive is larger for the long-term common owner than the SRI. We find that if willingness to pay is high enough, then mark-ups are high and as a result the marginal profit from an additional unit of production may balance the marginal damage from climate change for the SRI such that the SRI will not reduce revenue even though they are reducing quantities. On the other hand, under conditions of high mark-ups, a common owner might still prefer a decrease in quantities sufficiently large to result in a decrease in revenue if their inter-industry ownership is sufficiently large.

We highlight, however, that the long-term common owner has not been fully differentiated from the SRI. The separation derived above between the long-term common owner and SRI occurs only for high levels of inter-industry common ownership. In Appendices A.3.7.3 to A.3.7.11, we present results where the conditions are independent of the level of common ownership, depend on the level of intra-industry common ownership, and depend on both intra- and inter-industry common ownership.⁵³ In these results, it is also the case that separation, where plausible, only occurs for high levels of common ownership. Thus, in the next section we investigate conditions under which separation may occur for low levels of some common ownership parameters.

⁵²For this specific Proposition, see Appendix A.3.7.3, A.3.7.4 and A.3.7.5

⁵³Of these conditions, those in Proposition 9 seemed to strike the best balance between understand-ability and empirical applicability. However, the results under the conditions which depend on common ownership are similar to those presented in Proposition 9: if willingness to pay is high, common ownership is sufficiently high, and revenue is a non-monotonic function of quantities, then the long-term common owner will reduce revenue whilst the SRI will not. This separation, however, only occurs for sufficiently high common ownership rather than any level of common ownership.

2.3.4 Imperfectly competitive, commonly owned, exclusive suppliers

In the previous sections, we assumed that firms produced final goods with competitively priced inputs and placed no weighting on the payoffs of the firms producing those inputs. In this section, we relax that assumption to exploit a feature of common ownership; common owners may care about consumers or suppliers if the consumer or supplier is commonly owned. Thus, in such a circumstance, the preferred quantities and emissions of a firm may resemble that of the stakeholder-oriented shareholder in that common owners may prefer increases or decreases relative to a short-term profit maximizer.⁵⁴ Indeed, in what follows we show that is the case. First, however, we outline some extensions to the model and objective functions to allow for imperfectly competitive, commonly-owned, exclusive suppliers.

2.3.4.1 Extension to the model

We extend the model as follows. We introduce two supplying firms, $j = 1, 2$ in Sector S . Firm j in Sector S exclusively supplies an input, s_j , to firm i in Sector Q , where $j = i$. The production technologies are $q_i = \min(\frac{1}{c_F} L_Q, s_j)$ and $s_j = \frac{1}{c_I} L_S$. Firm j sets its price, p_j , after which firm i decides its production, q_i , in Cournot duopoly. The production of input s_j results in emissions of e_j , where units for emissions are chosen such that $e_j = s_j$. Total emissions is now given by $E = E_0 + e_i + e_{-i} + e_j + e_{-j}$. The firms in Sector S are owned by each institutional investor m , whose ownership is represented by $w_{S_Q,j,m}$, and retail investors, whose ownership is represented by c_S . Similar to the previous model, firm objectives are the active ownership objective of the institutional investor with the majority share, and institutional investors are assumed to have symmetric active ownership objectives.

With these extensions, the objective function of the short-term common owner is given by:

$$\tilde{\phi}_{STCO} = \pi_{Q,i} + \lambda_{INTRA,Q} \pi_{Q,-i} + \lambda_{INTER,S} \pi_{S,j} + \lambda_{INTER,S} \lambda_{INTRA,S} \pi_{S,-j} + R. \quad (2.31)$$

where $\lambda_{INTER,S} = \frac{(1-c_S)w_{S,j,m}}{(1-c_Q)w_{Q,i,m}}$ and R captures the profits of the firms not linked to the supply chain through product market interactions. It will be assumed that $\lambda_{INTRA,Q} = \lambda_{INTRA,S} = \lambda_{INTRA}$. The objective function of the long-term common owner is given by:

$$\tilde{\phi}_{LTCO} = \tilde{\phi}_{STCO} - \delta \gamma_{LTCO} E. \quad (2.32)$$

The objective function of the stakeholder-oriented shareholder now includes the profits of their exclusive supplier:

$$\phi_S = \pi_{Q,i} + \theta \pi_{S,j} + \theta U_{cw}(Q, R_n, y) - \delta \gamma_S E,$$

⁵⁴Since we model mitigation and adaptation as separable from the quantity choice, the mitigation and adaptation results remain similar to previous sections.

The objective functions of other owner types remains the same as Section 2.2.2. Note that these objective functions are defined from the perspective of the firm, not the investor. So, for example, despite the investor's portfolio interests, when investors implement an SRI objective, the objective for firm j in Sector S is:

$$\phi_{SRI} = \pi_{S,j} - \delta\gamma_{SRI}E = \phi_{STP} - \delta\gamma_{SRI}E \quad (2.33)$$

2.3.4.2 Quantities and emissions for all active ownership objectives

Here we focus on the best response quantities of firm i in Sector Q given prices from firms in Sector S_Q .⁵⁵ The results for investments in mitigation and adaptation remain identical to those already presented since investments in mitigation and adaptation are modelled as separable from quantity choices. We then combine the best response quantities with mitigation results to determine results for emissions.

The best response quantities of firm i in Sector Q given prices from firms in Sector S_Q , \bar{p}_j , under each active ownership objective can be summarized by:

$$q_{i,\phi}^* = A_\phi - B_\phi\bar{p}_j + C_\phi\bar{p}_{-j}, \quad (2.34)$$

where ϕ signifies the active ownership objective. Specifically, $A_\phi = \frac{(a-\tilde{c}_{F,STP})}{3}$, $B_\phi = \frac{2}{3}$, $C_\phi = \frac{1}{3}$ for the short-term profit maximizer, $A_\phi = \frac{(a-\tilde{c}_{F,LTP})}{3}$, $B_\phi = \frac{2}{3}$, $C_\phi = \frac{1}{3}$ for the long-term profit maximizer, $A_\phi = \frac{(a-\tilde{c}_{F,SRI})}{3}$, $B_\phi = \frac{2}{3}$, $C_\phi = \frac{1}{3}$ for the SRI, $A_\phi = \frac{(a-\tilde{c}_{F,S})}{3-2\theta}$, $B_\phi = \frac{(2-\theta)(1-\theta)}{3-2\theta}$, $C_\phi = \frac{(1-\theta)^2}{3-2\theta}$ for the stakeholder oriented shareholder, $A_\phi = \frac{(a-\tilde{c}_{INTER,S})}{3+\lambda_{INTRA}}$, $B_\phi = \frac{2(1-\lambda_{INTER,S})}{(3+\lambda_{INTRA})(1-\lambda_{INTRA})}$, $C_\phi = \frac{(1+\lambda_{INTRA})(1-\lambda_{INTER,S})}{(3+\lambda_{INTRA})(1-\lambda_{INTRA})}$ for the short-term common owner, and $A_\phi = \frac{(a-\tilde{c}_{LTCO})}{3+\lambda_{INTRA}}$, $B_\phi = \frac{2(1-\lambda_{INTER,S})}{(3+\lambda_{INTRA})(1-\lambda_{INTRA})}$, $C_\phi = \frac{(1+\lambda_{INTRA})(1-\lambda_{INTER,S})}{(3+\lambda_{INTRA})(1-\lambda_{INTRA})}$ for the long-term common owner, where $\tilde{c}_{F,STP} = c_F + t$, $\tilde{c}_{F,LTP} = \tilde{c}_{F,STP} + 2\delta\gamma_f$, $\tilde{c}_{F,SRI} = \tilde{c}_{F,STP} + 2\delta\gamma_{SRI}$, $\tilde{c}_{F,S} = \tilde{c}_{F,STP} + \theta\tilde{c}_{I,STP} + 2\delta\gamma_S$, $\tilde{c}_{I,STP} = c_I + t_{e_j}$, $\tilde{c}_{INTER,S} = \tilde{c}_{F,STP} + \lambda_{INTER,S_Q}\tilde{c}_{I,STP}$, and $\tilde{c}_{LTCO} = \tilde{c}_{INTER,S} + 2\delta\gamma_{CO}$.

For similar reasons to previous results, the long-term profit maximizer and SRI always reduce quantities and emissions relative to the short-term profit maximizer. We therefore do not cover these results in detail. Rather, we focus on the results for common owners and stakeholder-oriented shareholders.

⁵⁵These prices are equilibrium prices. Given the focus on final goods and services throughout the paper, we focus on Sector Q .

2.3.4.3 Quantities and emissions for common owners

The results for the common owners are summarized in the following proposition.

Proposition 10. *Quantities relative to the benchmark model (that is, the short-term profit maximizer) are:*

- i. a. If $\lambda_{INTRA} < \lambda_{INTRA}^*$, lower [higher] for the short-term common owner for $\lambda_{INTER,S} < \lambda_{INTER,S}^*(\lambda_{INTRA})$ [$\lambda_{INTER,S} > \lambda_{INTER,S}^*(\lambda_{INTRA})$].
- b. If $\lambda_{INTRA} > \lambda_{INTRA}^*$, lower for the short-term common owner for all inter-industry supply chain incentives $\lambda_{INTER,S} > 0$.
- ii. a. If $\lambda_{INTRA} < \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, lower [higher] for the long-term common owner for $\lambda_{INTER,S} < \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$ [$\lambda_{INTER,S} > \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$].
- b. If $\lambda_{INTRA} > \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, lower for the long-term common owner for all inter-industry supply chain incentives $\lambda_{INTER,S} > 0$ and inter-industry incentives $\lambda_{INTER} > 0$.

where $\lambda_{INTRA}^* = \frac{2\bar{p}_j - \bar{p}_{-j} - \tilde{c}_{I,STP}}{\bar{p}_{-j} - \tilde{c}_{I,STP}}$ and $\lambda_{INTRA}^*(\delta, \lambda_{INTRA}) = \frac{2\bar{p}_j - \bar{p}_{-j} - \tilde{c}_{I,STP} - 2\lambda_{INTRA}^2 \delta \gamma_f}{\bar{p}_{-j} - \tilde{c}_{I,STP}}$, and $\lambda_{INTER,S}^*(\lambda_{INTRA}) > 0$ and $\lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}) > 0$.⁵⁶

In contrast to previous propositions assuming perfectly competitive inputs, the firm-level behaviour implied by common ownership is now ambiguous. If the anti-competitive incentive, λ_{INTRA} , is sufficiently large, common owners always reduce quantities relative to the short-term profit maximizer regardless of the magnitude of the inter-industry supply-chain incentive, $\lambda_{INTER,S}$. However, if the anti-competitive incentive is sufficiently small, common owners may or may not reduce quantities relative to the short-term profit maximizer depending on the magnitude of the inter-industry supply-chain incentive. Specifically, if the anti-competitive incentive is sufficiently small and the inter-industry supply chain incentive is sufficiently small, then common owners reduce quantities similar to previous propositions. However, if the anti-competitive incentive is sufficiently small and the inter-industry supply chain incentive is sufficiently large, then, unlike previous propositions, common owners increase quantities relative to the short-term profit maximizer.

The asymmetry in the consequents of Proposition 10 can be understood as follows. Since it is not necessarily the case that $\bar{p}_j = \bar{p}_{-j}$, quantities are strategic substitutes and $q_i = s_j$, a common owner must in their purchasing decision from firm j trade-off the increase in profit for firm j , $\bar{p}_j - \tilde{c}_{STP}$, against the decrease in profit for firm $-j$, $\bar{p}_{-j} - \tilde{c}_{STP}$. Thus, if the profit margin for firm $-j$ is sufficiently large, the common owner has not only the usual anti-competitive incentive to reduce production in the product market for good q , but also the additional incentive

⁵⁶The expressions for these terms are relatively complex, so are included in Appendices A.3.8.2.1 and A.3.8.2.2

to reduce its production so that profits can be directed towards the relatively more profitable firm $-j$. If this is the case, the magnitude of $\lambda_{INTER,S}$ does not matter to the common owner since the common owner's share of the profit that is directed to firm $-j$ is sufficient to compensate the loss in the common owner's share in profit at firm j . However, if the profitability of firm $-j$ is not sufficiently large, then the common owner would prefer profit were directed to firm j , and must therefore trade-off the anti-competitive incentive to reduce production in the product market for good q against the incentive to expand its production to benefit firm j .

This is perhaps seen more clearly in the following Corollary. Since, under the symmetric common ownership assumption, the intra-industry incentives are bounded, i.e. $0 < \lambda_{INTRA} \leq 1$, the proposition can be reformulated with different antecedents as follows.

Corollary 5. *Quantities relative to the benchmark model (that is, the short-term profit maximizer) are:*

- i. a. *If $\bar{p}_j - \tilde{c}_{I,STP} > \bar{p}_{-j} - \tilde{c}_{I,STP}$, lower [higher] for the short-term common owner for $\lambda_{INTER,S} < \lambda_{INTER,S}^*(\lambda_{INTRA})$ [$\lambda_{INTER,S} > \lambda_{INTER,S}^*(\lambda_{INTRA})$].*
- b. *If $\bar{p}_{-j} - \tilde{c}_{I,STP} > 2(\bar{p}_j - \tilde{c}_{I,STP})$, lower for the short-term common owner for all inter-industry supply chain incentives $\lambda_{INTER,S} > 0$.*
- ii. a. *If $\bar{p}_j - \tilde{c}_{I,STP} - \delta\gamma_f > \bar{p}_{-j} - \tilde{c}_{I,STP}$, lower [higher] for the long-term common owner for $\lambda_{INTER,S} < \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$ [$\lambda_{INTER,S} > \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$].*
- b. *If $\bar{p}_{-j} - \tilde{c}_{I,STP} > 2(\bar{p}_j - \tilde{c}_{I,STP})$, lower for the long-term common owner for all inter-industry supply chain incentives $\lambda_{INTER,S} > 0$ and inter-industry incentives $\lambda_{INTER} > 0$.*

where $\lambda_{INTER,S}^*(\lambda_{INTRA}) > 0$ and $\lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}) > 0$. If neither of the antecedents in i. and ii. hold, that is, if $\bar{p}_{-j} - \tilde{c}_{STP}$ lies in the intermediate regions, then refer to Proposition 11.

Thus, if firm $-j$ is twice as profitable as firm j , the common owner always prefers to restrict production regardless of the value of λ_{INTRA} . However, if firm j is more profitable (net of damage from emissions for the long-term common owner) than firm $-j$, then the common owner's preferred firm behaviour depends on the inter-industry supply chain incentive as outlined Corollary 4. Finally, if the profitability of firm $-j$ lies somewhere in the intermediate range, the common owner's preference will depend on λ_{INTRA} .

From the above results for quantities, since $q_i = e_i$, it is clear that a common owner will reduce emissions whenever it reduces quantities. It is, however, now possible that a common owner increases emissions at a firm. For the short-term common owner, an increase in emissions relative to the short-term profit maximizer occurs whenever an increase in quantities occurs. For

the long-term common owner, an increase in emissions occurs, if, when there is an increase in quantities, the increase in quantities results in a greater increase in emissions than the decrease in emissions that arises from an increase in mitigation. Compared to the results for quantities, this translates in an increase in the threshold on the inter-industry supply chain incentive, $\lambda_{INTER,S}$, required for an increase.

Proposition 11. *Emissions relative to the benchmark model (that is, the short-term profit maximizer) are:*

- i. If $\lambda_{INTRA} < \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, lower [higher] for the long-term common owner for $\lambda_{INTER,S} < \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}, \rho)$ [$\lambda_{INTER,S} > \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}, \rho)$].
- ii. If $\lambda_{INTRA} > \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, lower for the long-term common owner for all inter-industry supply chain incentives $\lambda_{INTER,S} > 0$ and inter-industry incentives $\lambda_{INTER} > 0$. where $\lambda_{INTRA}^*(\delta, \lambda_{INTRA}) = \frac{2\bar{p}_j - \bar{p}_{-j} - \bar{c}_{I,STP} - 2\lambda_{INTRA}^2 \delta^{\gamma_f}}{\bar{p}_{-j} - \bar{c}_{I,STP}}$ and $\lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}, \rho) > \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}) > 0$.⁵⁷ For the results for the short-term common owner, refer to Proposition 10 and replace 'quantities' with 'emissions'.

Finally, unlike the results for stakeholder-oriented shareholders, the results for common owners cannot be further refined for cases where common owners definitively encourage particular directional changes in quantities or emissions. Definitive increases in quantities and emissions are not possible for the similar reasons as the stakeholder-oriented shareholder; $\lambda_{INTER,S}^*(\lambda_{INTRA}) > 0$ and $\lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}, \rho) > \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}) > 0$ so that there is always some λ_{INTER} small enough that a common owner prefers a decrease. Unlike the stakeholder-oriented shareholder, however, a definitive decrease in quantities or emissions cannot be deduced because $\lambda_{INTER,S}$ is not bounded above; there is always some possible $\lambda_{INTER,S}$ large enough that a common owner prefers an increase in quantities or emissions. Thus, for common owners in the imperfectly competitive supply chains modeled above, there are no conditions which definitively lead to either an increase or decrease in quantities or emissions.

⁵⁷The expressions for these terms are relatively complex, so are included in Appendices A.3.8.2.1 and A.3.8.2.2.

2.3.4.4 Quantities and emissions for stakeholder-oriented shareholders

The result for quantities for stakeholder-oriented shareholders is summarized in the following proposition.⁵⁸

Proposition 12. *Quantities relative to the benchmark model (that is, the short-term profit maximizer) are:*

i. *Lower for the stakeholder-oriented shareholder for all $0 < \theta \leq 1$ when $Q_{BMAM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j}) < 0$; and*

ii. *Lower [higher] for the stakeholder-oriented shareholder if and only if the stakeholder discount factor $\theta < \theta^*(\delta, \theta)$ [$\theta > \theta^*(\delta, \theta)$] when $Q_{BMAM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j}) > 0$.*

where $\theta^*(\delta, \theta) = \frac{2\delta\gamma_f}{Q_{BMAM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j})}$ and $Q_{BMAM}^* = 2q_{BMAM}^*$

The results of Proposition 12 can be understood in a similar manner to Proposition 2, however, in addition to considering the net benefits to the firm and stakeholders, strategic incentives become relevant.⁵⁹ First, when evaluating the benefits to stakeholders, not only does the stakeholder-oriented shareholder consider the marginal consumption benefit and marginal damage to society, $Q_{BMAM}^* - 2\delta(\gamma - \gamma_f)$, as per Proposition 2, the stakeholder-oriented shareholder now also considers the marginal benefit to their supplier, $\bar{p}_j - c_{I,STP}$. Second, the effect of the input price differential, $(2 - \theta)(\bar{p}_j - \bar{p}_{-j})$, on the strategic interaction between firms becomes relevant. Since quantities are strategic substitutes and stakeholder-oriented shareholders face a lower degree of strategic substitutability of quantities than short-term profit maximizers,⁶⁰ if firm i faces a lower input price than firm $-i$, i.e., $\bar{p}_j < \bar{p}_{-j}$, then the strategic incentive for firm i to expand production in reaction to the downward pressure on firm $-i$'s quantities from relatively higher input prices is lower for stakeholder-oriented shareholders than short-term profit maximizers. Thus, the threshold for which the stakeholder-oriented shareholder reduces quantities relative to a short-term profit maximizer increases as the input price differential decreases (and vice versa).

Thus, since all stakeholder-oriented shareholders increase mitigation relative to short-term profit maximizers, if a stakeholder-oriented shareholder reduces quantities, they will also reduce emissions. However, whenever stakeholder-oriented shareholders increase quantities, if the increase in quantities results in more emissions than the reduction in emissions from

⁵⁸The models and working for these results can be found in Appendix A.3.8.2.3.

⁵⁹This can also be seen by noting that the above condition equals the condition in Proposition 2 if inputs are sourced in perfectly competitive, non-emitting markets where $\bar{p}_j = c_{I,STP}$, $\bar{p}_j = \bar{p}_{-j}$, and the 2δ is instead δ (reflecting the fact that firm i considers only its emissions, and not its emissions and its supplier's emissions).

⁶⁰This is indicated by the cross-partial with respect to quantities being lower for stakeholder-oriented shareholders than short-term profit maximizers.

mitigation, a stakeholder-oriented shareholder may increase emissions. Like in the previous section, this translates in an increase in the threshold on the incentive parameter, in this case θ , required for an increase. Similar to Proposition 4, this result is summarized by the following proposition.

Proposition 13. *Emissions relative to the benchmark mitigation-adaptation model (that is, the short-term profit maximizer) are lower for the stakeholder-oriented shareholder if and only if the following holds:*

$$\frac{\theta(Q_{BMAM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j})) - 2\delta\gamma_f}{3 - 2\theta} < \frac{\delta\gamma_S}{\rho},$$

where $\gamma_S = \gamma_f + \theta(\gamma - \gamma_f)$ and $Q_{BMAM}^* = 2q_{BMAM}^*$. Specifically, if $\theta(Q_{BMAM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j})) < 0$, then the above condition implies that emissions are lower for all $1 \geq \theta > 0$.

Collecting the results of this section, the active ownership identification problem in the context of firms emitting GHG emissions and imperfectly competitive, commonly owned, exclusive suppliers can be summarized as follows.

Corollary 6 (The active ownership identification problem in the context of GHG emissions when firms have imperfectly competitive, commonly owned, exclusive suppliers). *When firms have imperfectly competitive, commonly owned, exclusive suppliers, and the relevant conditions from Propositions 10, 11 and 13 hold, then quantities and emissions relative to the benchmark model are lower for all active ownership objectives for all time discount factors $0 < \delta \leq 1$, SRI discount factors $0 < \beta \leq 1$, and stakeholder discount factors $0 < \theta \leq 1$.⁶¹*

⁶¹The common ownership incentives are omitted since they are no longer definitive directional results for common owners. See the discussion after Proposition 11.

2.4 Conclusion

In the preceding sections, we demonstrated the active ownership identification problem in the context of firm-level GHG emissions. We then presented one solution to this problem, which consists of hypotheses that may be applied to understanding the results of existing empirical studies or may be tested in future empirical studies.⁶² Our solution is summarized in Figure 2.2 below and essentially involves analyzing the outcomes of our model under different industry conditions to separate different active ownership objectives.

Our solution is subject to limitations, some of which offer interesting areas for future research. We have made several simplifying assumptions in our model. Here we discuss the impact of relaxing some those assumptions.⁶³ The first of these assumptions relates to our mathematical representation of damage from emissions and the relationship between quantities, mitigation, and adaptation. We have assumed that damage is linear in emissions, mitigation and adaptation, and that choices of quantities, mitigation and adaptation are independent of each other.⁶⁴ Relaxing these assumptions may change the equilibrium values and values of the industry conditions for separations. However, we do not believe that relaxing these assumptions would change the direction of the movement in equilibrium values nor the qualitative statements about the industry conditions required for separations.⁶⁵ Therefore, our key results would be maintained.

The second of these assumptions relates to the individual characteristics of consumer-workers, firms and institutional investors. We have assumed a linear demand function and constant marginal costs. Our key results would be maintained under general demand and cost functions for the same reasons as in the previous paragraph. An exception is Proposition 9, which relies on demand functions with revenue curves that are non-monotonic functions of quantities. Further, we have assumed the discount rates and incentives that appear in many of the institutional investors' possible active ownership objectives are not common across active ownership objectives. However, assuming common time discount rates is not unusual in other literatures. In Appendix A.4.1, we present results where we assume that active ownership objectives have a common but unknown time discount factor or intra-industry common owner-

⁶²For detail on empirically testing some of these hypotheses, please see the papers discussed throughout the body of this paper. These papers include Shive and Forster (2020), Azar, Duro, Kadach, and Ormazabal (2021), Akey and Appel (2019), Naaraayanan, Sachdeva, and Sharma (2020), Benlemlih, Arif, and Nadeem (2022).

⁶³See footnotes 22, 24, 28, 44, 48 and the final paragraph of Section 2.3.3 for discussions of other assumptions.

⁶⁴It is sometimes assumed in the literature that damage is a quadratic function of emissions and that the cross partial derivatives with respect to quantities, mitigation and adaptation are not zero such that the choices of each affect each other.

⁶⁵For example, convex damage functions, which are common in the climate economics literature, could be used. In this case, we believe that our results would remain qualitatively unchanged because, relative to the short-term profit maximizer, both linear and convex damage functions create an incentive to reduce production and invest in mitigation and adaptation.

ship incentive. However, to remain faithful to our research question investigating unknown, possibly heterogeneous objective functions we do not present these results in the body of this paper.⁶⁶

The third of these assumptions relates to the assumed benchmark model. To simplify our analysis, we create a benchmark model rather than using control weights between a benchmark and other objectives. We then assume (short-term) profit maximization as the firm objective in the benchmark model. This assumption appears to be the (perhaps implicit) assumption across the theoretical literatures on active ownership objectives.⁶⁷ Such an assumption, however, is unlikely to be empirically plausible since, in addition to the one institutional investor which is the focus of this paper, many economic agents (other shareholders, workers, consumers, management, directors, regulators etc.) may influence the corporate objective, for example, due to agency problems.⁶⁸ We see gaining further understanding of and overcoming this benchmark problem as a key area for future research that aims to solve the active ownership identification problem in natural experimental settings.

The last of these assumptions relates to our corporate governance process, with which there are two further limitations. First, it might appear that the corporate governance process modelled does not match the key independent variable in the empirical literature, ownership. The empirical literature on social responsibility predominantly uses ownership as an independent variable (e.g. Gillan, Koch, and Starks, 2021). The common ownership literature, whilst predominantly using measures of common ownership incentives as independent variables (e.g. Schmalz, 2018, 2021), has used ownership as a independent variable in the context of firm-level GHG emissions (e.g. Azar, Duro, Kadach, and Ormazabal, 2021). By using ownership as an independent variable, the dependent variable can be seen as a weighted function of shareholder

⁶⁶We have also assumed symmetric common ownership. Whilst common ownership is likely to be asymmetric in the real world, we believe our results under asymmetric common ownership would remain qualitatively similar because, relative to the short-term profit maximizer, the directional effects of incentives under asymmetric common ownership are similar to the directional effects of incentives under symmetric common ownership; there is the anti-competitive incentive to reduce production and the incentive to invest in mitigation to reduce damage to other firms.

⁶⁷The common ownership literature (e.g. Azar and Vives, 2021a) uses an objective function consisting of individual firm profits and other firms' profits, where the degree to which other firms' profits are considered is given by λ . If $\lambda = 0$, such an objective reduces to profit maximization. The CSR and SRI literature (e.g. Broccardo, Hart, and Zingales, 2020; Hart and Zingales, 2017) uses an objective function consisting of profits and damage from an externality, where the degree to which damage from a firm's activities is considered is given by λ . If $\lambda = 0$, such an objective also reduces to profit maximization. The literature that most closely resembles stakeholder theory (e.g. Magill, Quinzii, and Rochet, 2015) uses a weighted objective function of profits and consumer or worker utility, where the weighting given to consumer or worker utility is given by θ . If $\theta = 0$, such an objective again reduces to profit maximization.

⁶⁸Important in relation to this point and as noted in a previous footnote, the results of our paper do not entirely explain the results in Akey and Appel (2019). They find a statistically insignificant negative correlation between hedge fund activism and mitigation. However, our paper does not predict a negative change in mitigation for any active ownership type relative to the short-term profit maximizer. Our suspicion, which is somewhat corroborated by the discussion in Akey and Appel (2019) about the profit-oriented nature of hedge funds, is that the benchmark is not profit maximisation in the sample of Akey and Appel (2019).

preferences over the dependent variable, where the weighting is ownership and the regression coefficients are the shareholder preferences. In a model that is simplified to two distinct groups of sincere shareholders who share control over firm-level choices, the first derivative of the weighted function of shareholder preferences with respect to one shareholder's ownership, and thus the regression coefficient on this shareholder's ownership, is the difference between the two shareholder's preferences.⁶⁹ This difference has been the subject of our analysis throughout the paper. Thus, whilst not appearing to match the approach of the empirical literature, we do indeed model the approach in the empirical literature on active ownership objectives. Second, whilst we do follow the approach of the empirical literature, the corporate governance process we have modelled is relatively simple. Such a simplified model may not be empirically plausible for the same reasons as in the previous paragraph. Exploring the implications of the design of the corporate governance process is another important area for future research on the active ownership identification problem.

Finally, we believe this paper has considerable implications for academics, practitioners, regulators and policymakers. The active ownership identification problem in the context of firm-level GHG emissions sits at the nexus of greenwashing and financial product promises more broadly,⁷⁰ competition policy and facilitating a just transition. As noted at the outset of the paper, institutional investor's active ownership policies may contain promises to influence firms on particular issues, such as climate change, in accordance with a particular active ownership objective. But the focus of greenwashing to the best of our knowledge has been on whether institutional investor influence is used to address the issue of climate change, not whether influence is used in accordance with the promised or implied active ownership objective. Would or should, say, a consumer or provider of a financial product care if outcomes were improved through SRI versus common ownership? Such a question also highlights the implications for competition regulation and policy. Is an action socially responsible or is the cloak of social responsibility being donned for anticompetitive (common ownership) purposes? Finally, in light of skewed corporate equity ownership exacerbating inequality and the possible relation to common ownership (e.g. Gans, Leigh, Schmalz, and Triggs, 2019), it might be asked; which objective is most consistent with (the promise of) facilitating a just transition? In answering these questions, it will be of import to solve the active ownership identification problem.

⁶⁹See Appendix A.4.2

⁷⁰Through, for example, the environmental promises made in institutional investors' active ownership policies.

Chapter 3

A simple, power-based framework for analyzing an agent's effect on social choices

Abstract

I refine what I call the “power-based approach” to estimating and interpreting the effect of an agent on the social choice of a group of agents. Power-based approaches are an applied empirical practice that involves estimating, interpreting and characterizing OLS regression coefficients from linear regressions of group choices on a proxy for the “power” of an agent of interest. Based on this applied empirical practice, I develop a framework that assists in interpreting the estimated effects, developing bounds on effects, constructing identification arguments and developing measures of “power”. I demonstrate the usefulness of this framework through an application to Ashraf, Field, and Lee (2014), who conducted a field experiment in which wives are given a voucher for contraception either with their husband or in secret from their husband. Using the power-based framework, I show that the interpretation of the results of Ashraf, Field, and Lee (2014) with respect to female empowerment may be the opposite of the interpretation of the authors and argue that their estimated average treatment effect, which captures the effect of treating power and preferences, is an overestimate of the average treatment effect of treating power only.

3.1 Introduction

It is often of interest to investigate the effect of an agent on social choices. A common method for estimating this effect in both experimental and observational empirics is to use what I call a "social choice power regression." A social choice power regression is a linear regression of social choices on a plausible proxy for an agent's power to affect (or ability to influence or control) a group's social choices and a set of controls. The hypotheses, explanations and interpretations of the estimated coefficients of the proxy for power are often based on the preferences of the agent of interest and an assumption about the relationship between the proxy for power and power itself. Examples include research into the effect of shareholders on firm decisions through shareholder ownership rights (see, for example, the reviews of Boyd and Solarino, 2016; Brown, Beekes, and Verhoeven, 2011; DesJardine, Zhang, and Shi, 2023; Edmans, 2014; Gillan, Koch, and Starks, 2021; Holderness, 2003; Shleifer and Vishny, 1997), the effect of firms, non-corporate organizations and individuals on government decisions through political donations and lobbying (see, for example, the reviews of Bombardini and Trebbi, 2020; Figueiredo and Richter, 2014; Stratmann, 2005), and the effect of males or females on household decisions through, for example, income and age differentials and decision-making authority (see, for example, the reviews of Almås, Attanasio, and Carneiro, 2023; Gomes, Haliassos, and Ramadorai, 2021; Munro, 2018).¹

Despite the widespread use of social choice power regressions, there has, to the best of my knowledge, been no research into the micro-foundations, interpretation and structural estimation of these regressions.² For example, what underlying micro-economic structure rationalizes the use of social choice power regressions? How does one interpret the estimated coefficients? How may the estimated coefficients reflect the preferences of the agent of interest or the effect of the proxy on power as is usually hypothesized, explained or interpreted? Can statistics related to these preferences be estimated by social choice power regressions, and, if so, how?

In this paper, I develop a simple framework to begin answering these questions. I focus on an experimental set-up with a social choice power regression that consists of a binary treatment variable and intercept term only, and use Ashraf, Field, and Lee (2014) ('AFL') as an

¹There are likely many more areas of research which may include examples of papers using social choice power regressions since the approach may be relevant wherever a social choice is made. For brevity, here I list areas of research relevant to firms, governments, and households, due to the importance of these three organizational types and their social choices. However, the use and potential application of social choice power regressions may be even broader than indicated by the examples provided here.

²By micro-foundations of the regression, I mean not only that there is a theoretical model used for hypothesis development, or explanation and interpretation of the results, but that the econometric specification is also a theoretically derived model as in, for example, structural models, where the interpretation and identification of economically useful information and statistics (such as those relating to the preferences of agents) is explicit. This paper may be seen as an attempt to provide a structural model for social choice power regressions, which are currently reduced-form models.

example throughout. To develop the framework, I first construct a simple equation based predominantly on assumptions from the literature applying from social choice power regressions. In this equation, social choices are power-weighted combinations of agents' most-preferred social choices (the 'power-weighted social choice function'). Using near-standard aspects of social choice theory, I then show that the power-weighted social choice function may have micro-foundations as a ("reduced-form") description of the outcome of an equilibrium selection procedure. AFL, an innovative and highly cited experimental field study, is used as an example throughout to demonstrate the potential importance of the results of applying the framework where a social choice power regression is used. AFL use an experiment to study the effect of moral hazard on contraceptive use in households in Zambia in 2007. AFL's experiment involved a control group in which wives individually received a voucher for free access to family planning services, which included free access to concealable contraceptives, ('Individual' treatment) and a treatment in which wives and husbands jointly received the voucher with the voucher handed to the husband ('Couple' treatment). Thus, the treatment indicator can be viewed as the proxy for power between wives and husbands, and the social choice as use of the voucher.

Using the framework, I then provide sufficient conditions for robust interpretation³ of social choice power regressions. Following the literatures applying social choice power regressions, I interpret results as what can be conceived as a 'tug-of-war' between two agents, the agent of interest and a benchmark agent, over a social choice (even if more than two agents are involved). Given this, the sign of the coefficient for the proxy for the power of the agent of interest in social choice power regressions can be expressed as the product two components; the effect of the proxy on power, and the difference between the most-preferred social choices of the agent of interest and the benchmark agent. Thus, assuming agents' most-preferred social choices are not functions of the proxy for power and given the sign of the coefficient from the social choice power regression, inferences can be made about the sign of one of the terms in this product if valid assumptions can be made about the sign of the other term in the product. Whilst straightforward, such a result has potentially important consequences for interpretation, and, therefore, subsequent use of results, as I demonstrate in the case of AFL. In AFL, the key takeaway appears to have been that Couple treatment disempowered wives.⁴ However, using assumptions based only on information in AFL, application of the above robust approach to interpretation implies that deciding as a couple may have weakly empowered (disempowered) the majority (a minority) of wives in the sample.⁵

³That is, interpretations that are robust to any distribution of variables.

⁴In the section addressing this point, I provide quotes from AFL that indicate as such. When citing AFL, this conclusion is re-reported, for example, in Doepke and Kindermann (2019).

⁵Since this paper is primarily focused on demonstrating the use of the framework, I attempt to stay as close to AFL as possible. However, there are some assumptions of AFLs, and assumptions I derive from AFL, that may potentially affect this conclusion. When I address these assumptions, the conclusion becomes relatively more complex. A key takeaway relevant here, however, is that deciding as a couple may have strictly empowered 21% of

I then turn to interpreting the results of experiments where the proxy for power also affects preferences, with two key results. First, I provide an approach for deriving the average treatment effect in the experiment as a bound on the effect of the ideal experiment in which only power was manipulated. Application of this result to AFL indicates that the average treatment effect in AFL's experiment, which is negative, may be an upper bound on the effect in an experiment in which only power is manipulated.⁶ Second, I find that a 2x2 factorial experimental design and various statistics that could be collected about agents' preferences could be used to test the assumption in some experiments of intra-household decision-making that the experimental manipulation of preferences did not affect power and differences in preferences among agents (see, for example, Ashraf, Field, and Lee, 2014; Augsburg, Malde, Olorenshaw, and Wahhaj, 2023).

Finally, I turn to the structural estimation of social choice power regressions and the power-weighted social choice function, where the intent is to recover parameters of agents' most-preferred social choices. I propose an approach for measuring power using a validation dataset that satisfies the moment condition required for the identification of the mean most-preferred social choice of the benchmark agent and the difference between the mean most-preferred social choices of the agent of interest and the benchmark agent.⁷ I demonstrate this approach using the AFL dataset and show that this approximation approach outperforms the naïve approach of simply interpreting the treatment indicator as the approximation for power and a prediction-based approach that uses treatment to predict power. The approach, however, does require a validation dataset, which can be challenging to obtain.

These results contribute to the following literatures. First, the simple framework developed in this paper can be utilized by all literatures that apply social choice power regressions, which includes, but is not limited to, those listed in the first paragraph of this section. Whilst these papers often use other frameworks, particularly for theory and hypothesis development,⁸ the primary advantage of the framework presented in this paper relative to other frameworks is its theoretical simplicity and broad empirical applicability.⁹ Furthermore, the framework presented in this paper is a perhaps at times simplistic but, I believe, pragmatic attempt at

wives "as a whole", and strictly disempowered 23% of wives (not as a whole). "As a whole" is intended to indicate that there are some wives in the 21% who were disempowered, however, the "dominant effect" appears to have been empowerment. For detail, see Appendix B.1 and the findings in Section 3.3.2 and Section 3.3.3.

⁶By providing a voucher for free family planning services, there is an asymmetric effect on the most-preferred choices of wives and husbands because husbands do not know about the voucher if the voucher is only given to the wives. Thus, in addition to the effect of treatment on power, there is also an effect of treatment on preferences.

⁷The mean most-preferred social choice of the agent of interest is, therefore, also identified.

⁸For example, AFL rely on collective bargaining and non-cooperative models for their theory and hypothesis development. However, AFL do not use these models in their empirical modeling. Therefore, there is a gap between their theoretical model and empirical model.

⁹The differences between the framework presented in this paper and other frameworks are further discussed in Section 4.4. Furthermore, the framework in this paper can nest every other framework that relies on an equilibrium concept.

bridging the gap between structural models, which are often infeasible, and reduced-form models, which necessarily have a structure even if it is implicit, in the literatures that apply social choice power regressions. Also, by using AFL as an example, I contribute directly the literature on household fertility choices (see, for example, Doepke, Hannusch, Kindermann, and Tertilt, 2023; Doepke and Kindermann, 2019) and intra-household bargaining (see, for example, Almås, Attanasio, and Carneiro, 2023) by provided an updated interpretation of the results in AFL¹⁰ and showing that the effect of treatment may have been overestimated relative to the effect of treatment many may have in mind when discussing the results.

Second, I contribute to the literatures that use structural models to construct bounds for average treatment effects (see, for example, Gardner, 2023; Gardner, 2020) or to motivate experimental design (see, for example, Quidt, Haushofer, and Roth, 2018).¹¹ Relative to these papers, the model and results in this paper are very simple. However, whilst simple, this paper is, to the best of my knowledge, the first to consider such problems from the perspective of treatment affecting social choices that are determined by multiple agents rather than treatment affecting choices made by a unitary decision-maker, where, importantly, treatment may affect each agent differently.

Third, I also contribute to the literature on the measurement of latent variables using predictive models developed in validation datasets (see, for example, Knox, Lucas, and Cho, 2022; Yang, Adomavicius, Burtch, and Ren, 2018).^{12, 13} To the best of my knowledge, the closest paper in this area, based on its focus on power, is Carroll and Kenkel (2019). Carroll and Kenkel (2019) construct a predictive model for military power, which is measured as the probability that one state will defeat another in conflict, and argue for the validity of their proxy based on its ability to predict outcomes with which the proxy is supposed to be associated (such as the outcomes of negotiations between states). In contrast, I construct a predictive model for power over social choices and argue for its validity based on its ability to identify structural parameters of interest. Other closely related papers, in terms of method, are Fong and Tyler (2021) and Yang, McFowland, Burtch, and Adomavicius (2022). Both Fong and Tyler (2021) and Yang, McFowland, Burtch, and Adomavicius (2022) outline instrumental-variable-based methods for identification based on the weak exogeneity assumption between errors and latent variables or instruments. In contrast, since such an assumption is unlikely to hold for the correlated random coefficients model in this paper, I construct the predictive model for power such that the predictive model (which is used to measure power) satisfies the weak exogeneity

¹⁰Given the complexity of the interpretation, please see Appendix B.1 for details.

¹¹This literature is therefore also part of the literature on bounding treatment effects and, more generally, partial identification (see, for example, Molinari, 2020) and experimental design (see, for example, Kagel and Roth, 2016).

¹²As noted in Yang, McFowland, Burtch, and Adomavicius (2022), this literature is similar to the literature on generated regressors.

¹³For a review focused on measurement error, see Schennach (2022).

assumption in the structural equation. Unlike the settings of Fong and Tyler (2021) and Yang, McFowland, Burtch, and Adomavicius (2022), this can be done in the setting of this paper because there are sufficient variables in the validation set for there to be no unobservables in the power weighted social choice function.¹⁴

The rest of the paper proceeds as follows. In Section 3.2, I develop and provide micro-foundations for the power-weighted social choice function. In Section 3.3, I apply the power weighted social choice function to the interpretation of the results from social choice power regressions, to bounding treatment effects and testing assumptions through experimental design, and to develop a measure of power for use in structural estimation. Finally, in Section 3.4, I conclude.

¹⁴Given power is a latent variable, it may seem contradictory to claim to rely on no unobservables. However, in the model in this paper, power is the kind of latent variable that can be constructed, or measured, given the necessary observables. Specifically, in the validation set where social choices and agents' most-preferred social choices are known, it is possible to measure power by solving for the weights that satisfy the power-weighted social choice function. In contrast, in the validation sets used by Fong and Tyler (2021) and Yang, McFowland, Burtch, and Adomavicius (2022), either the error terms or the coefficients of their regression equations remain unknown, which precludes the adoption of the approach in this paper for their problem.

3.2 Framework: Connecting social choices to power

This section contains two simple results. In the first, I provide a simple equation linking social choices to power that is consistent with common assumptions from papers applying social choice power regressions. In this equation, social choices are expressed as power-weighted functions of agents' most-preferred social choices (the 'power-weighted social choice function'). In the second, I provide simple micro-foundations for the power-weighted social choice function using social choice theory. These micro-foundations have two core components: a set of feasible social choices (or equilibria) and a social choice (or equilibrium) selection procedure. The social choice selection procedure is one in which a mechanism designer selects the social choice.

3.2.1 The power weighted social choice function

To derive the power-weighted social choice function, I rely on the following two sets of assumptions: those based on observation of common empirical practices and those based on intuitions about power. The assumptions primarily based on observations of common empirical practices are Linearity, Coefficients Reflect Preferences and Non-Negativity of Power, which I describe further below. The assumptions that are primarily based on intuitions about power, which I also describe further below, are Power Scarcity and Coefficients Reflect Most-Preferred Social Choices.¹⁵

Linearity requires that social choices are linear functions of each agent's power. This assumption is motivated by the common practice of modeling social choices as linear functions of the proxies for the power of the agent of interest.

Assumption 1. (*Linearity*)

$$c = \sum_j \beta_j \rho_j$$

where c is a social choice, j indexes agents, and ρ_j is an agent's power.

Coefficients Reflect Preferences requires that the coefficients of the linear function are functions of agent's preferences, \succsim_j . This assumption is based on observing papers that use conjectures about the preferences of the agents of interest to hypothesize, explain and interpret these coefficients as the effects of the agent of interest on social choices in social choice power regressions.

Assumption 2. (*Coefficients Reflect Preferences*) $\beta_j := \beta_j(\succsim_j)$, where \succsim_j represents an agent's preferences.

¹⁵The steps in this section are intermediate steps to deriving social choice power regressions. In Section 3.3 below, I show how to recover social choice power regressions from the power-weighted social choice function established in this section.

Non-negativity is motivated by observations of practice and intuitions about power.¹⁶ Proxies for power are commonly non-negative. Power being non-negative may also be intuitively appealing as it is common to talk about having no or little power, but not negative power.

Assumption 3. (*Non-Negativity*) $\rho_j \geq 0$ for all j .

The assumptions that appeal to intuitions about power are Power Scarcity and Coefficients Reflect Most-Preferred Social Choices. Power Scarcity relies on the same intuitive argument about the non-negativity of power whilst also noticing that in situations where agents have little or no control it is common to talk about one agent having full control over an outcome. Thus, the total amount of power must in some sense be finite regardless of the number of agents. That is, $\infty > \sum_j \rho_j = K > 0$. Furthermore, the agent with full control implements their most-preferred social choice.¹⁷ If this is the case and Assumptions 1-3 hold, then it must be that if an agent, say D , has full control, then $\beta_D(\succsim_D) = \frac{c_D}{K}$, where c_D is the most preferred social choice of agent D . Note, however, that since what is meant by “full” control is only taken to be finiteness and since for every K , if $\rho_j = K$, then $c = c_D$, K may be considered an arbitrary constant. Since K is arbitrary, I normalize $K = 1$ for simplicity. Thus, for Assumptions 1-3 to be consistent with the possibility of any agent having full control and assuming $K = 1$, it must be that following hold.

Assumption 4. (*Power Scarcity*) $\sum_j \rho_j = 1$.

Assumption 5. (*Coefficients Reflect Most-Preferred Social Choices*) $\beta_j(\succsim_j) = c_j$, where c_j is the most-preferred social choice of agent j .

Given Assumptions 1-5, it is immediate that social choices can be expressed as power-weighted functions of each agent’s most-preferred social choice.

Proposition 14. (*Power-weighted social choice function*) Assumptions 1-5 if and only if:

$$c = \sum_j c_j \rho_j$$

where $\sum_j \rho_j = 1$ and $\rho_j \geq 0$ for all j .

¹⁶One exception is where differentials in variables are used, such as, for example, income differentials in Aizer (2010). However, such differentials can be conceived as power differentials.

¹⁷It is assumed that agents have strict preferences so that they have a single most-preferred social choice.

3.2.2 Micro-foundations for the power weighted social choice function

The power-weighted social choice function may be an intuitively appealing representation of social choices and power. However, does the power-weighted social choice function have economic foundations? In this section, I show that it may. Specifically, I show that, under simplified, near-standard social choice theory assumptions,¹⁸ the power-weighted social choice function exists. However, there are also circumstances in which the power-weighted social choice function may not exist. I therefore introduce an ‘error’ term into the power-weighted social choice function to account for these circumstances.

Three sufficient conditions for the existence of the power-weighted social choice function are as follows. First, there is a set of feasible social choices (or social choice functions) at a point in time, where social choices are the equilibria of some game.¹⁹ These social choices are unidimensional and non-random.

Supposition 1. *(Social choice functions are unidimensional constants) A social choice function determines a single, constant social choice only, that is, $f(\cdot) = c \in F \subset \mathbb{R}$, where F is the set of feasible social choices.*

Second, there is a mechanism designer that selects the social choice to be implemented from the set of feasible social choices. This mechanism designer has strict preferences over the set of feasible social choices.

Supposition 2. *(Equilibrium selection by a mechanism designer) There is a mechanism designer that chooses a social choice function from the set of feasible social choice functions. This mechanism designer, agent 0, has strict preferences over the feasible social choice functions, F , with most-preferred social choice function $c_0 \in F$ such that for all $y \neq c_0$:*

$$u_0(c_0, \Theta, \omega_0) > u_0(y, \Theta, \omega_0),$$

where $u_0(\cdot)$ is the utility function of agent 0, Θ is the set of agent types, and ω_0 is agent 0's information and endowment.²⁰

Finally, the mechanism designer is assumed to be an agent, which permits inclusion of the mechanism designer in the set of agents regardless of whether the mechanism designer has an empty strategy set in the games underlying social choices.

¹⁸I deviate slightly from standard social choice theory assumptions by assuming that the mechanism designer is in the set of agents. The assumptions are simplified in the sense that social choices are assumed to be unidimensional constants.

¹⁹The definition of feasible is intentionally omitted. The constraints determining feasibility will depend on the application.

²⁰Given Supposition 1, agents have complete information.

Supposition 3. (*The mechanism designer is an agent*)

Given Suppositions 1-3, the power-weighted social choice function exists.

Proposition 15. (*Power-weighted social choice function exists*) *Suppose Suppositions 1-3, then there exists a ρ_j such that:*

$$c = \sum_j c_j \rho_j$$

where $\sum_j \rho_j = 1$ and $\rho_j \geq 0$ for all j , and $c_j \in F$ for all j .

Proof: Since the mechanism designer decides from the set of feasible choices, there exists at least one solution at $\rho_0 = 1$.

Proposition 2, whilst simple, may be directly applicable in various circumstances. A common circumstance may be those in which an agent has responsibility for (or authority over) a social choice. For example, heads of households may be responsible for household decisions,²¹ whilst employees of both public and private organizations may be delegated responsibility for some organizational choices.²² Another common circumstance may be where an agent has sufficient resources to completely control a social choice (i.e. without formal or informal authority). For example, founders and major shareholders may have sufficient ownership to effectively determine some firm choices (see, for example, Gomez-Mejia, Larraza-Kintana, and Makri, 2003; Miller, Le Breton-Miller, and Lester, 2011), whilst it may be that corporations have some ability to significantly influence (perhaps to the point of controlling) government decisions (see, for example Zingales, 2017).²³

Proposition 2 may not apply in all circumstances, which is not necessarily problematic. Any set of alternative suppositions that implies $\max(c_j) \geq c \geq \min(c_j)$ will be sufficient for the power-weighted social choice function. For example, if instead of an agent selecting the social choice, two agents bargain over the choice under complete information or all agents involved vote under complete information, then $\max(c_j) \geq c \geq \min(c_j)$. If on the other hand it is not

²¹For example, responses to survey questions about the distribution of decision-making within a household are commonly used in empirical work related to power within households. See, for example, Cassidy, Groot Bruinderink, Janssens, and Morsink (2021) and Augsburg, Malde, Olorenshaw, and Wahhaj (2023), and the reviews of Gammage, Kabeer, and Meulen Rodgers (2016) and Donald, Koolwal, Annan, Falb, and Goldstein (2020).

²²See, for example, Aghion and Tirole (1997) and Bester and Krämer (2008) for seminal economic theory, and Meagher and Wait (2020) and Asuyama (2020) for recent empirical studies related to delegation.

²³The reasoning used here resembles the distinction between formal and real authority (Aghion and Tirole, 1997). The notion of power developed here, however, is different from the notions of formal and real authority developed by Aghion and Tirole (1997) in the following ways. First, real authority is binary whilst the above measure of power is not necessarily ($\rho_0 = 1$ is only one of possibly many solutions and the mechanism designer being an individual is not necessarily the only possibility, which I discuss in the next paragraph). Second, the test for which agent has real authority appears to be whether the firm choice is the firm choice that would have been made if the agent with formal authority decided themselves. In our set-up, however, such an arrangement may not be in the feasible set of social choice functions (as indicated by those cases where the agent with formal authority decides to delegate, implying not delegating is not an equilibrium of the delegation game).

the case that $\max(c_j) \geq c \geq \min(c_j)$, then the power-weighted social choice function does not follow. Even where there is a mechanism designer performing equilibrium selection, this may occur, for example, if social choices are multidimensional²⁴ or random.²⁵ To incorporate these possibilities, I include an ‘error’ in the power-weighted social choice function as follows.²⁶

Lemma 1. (*Power-weighted social choice function with error*)

$$c = \sum_j c_j \rho_j + \varepsilon$$

where $\sum_j \rho_j = 1$ and $\rho_j \geq 0$ for all j , $c_j \in F$ for all j , and:

- if $c < \min(c_j)$, $\varepsilon := c - \min(c_j)$ and $\rho_{min} = 1$, where ρ_{min} is the power of agent j' and agent j' is the agent for which $c_{j'} = \min(c_j)$,
- if $c < \max(c_j)$, $\varepsilon := c - \max(c_j)$ and $\rho_{max} = 1$, where ρ_{max} is the power of agent j'' and agent j'' is the agent for which $c_{j''} = \max(c_j)$,
- otherwise, $\varepsilon := 0$.

3.2.3 Example

In this section, I use a version of the Battle of the Sexes (Luce and Raiffa, 1957) as a simple example for Proposition 15 and Lemma 1, which I adapt to the fertility choice context similar to AFL. Suppose a husband and wife are deciding whether to visit the doctor to use a voucher for family planning services and the wife has asked her mother to be involved due to the mother’s experience in these matters. Since they would prefer the wife to have a child, the husband and mother prefer to go the family planning service and use the voucher (‘Visit’), whilst the wife is satisfied with her current approach to contraception so would prefer not to go to the family planning services (‘No Visit’). However, all would prefer to coordinate. As such, the corresponding payoffs are given in Figure 3.1 below. The family agree to select one family member to decide where to meet (the ‘mechanism designer’). The mechanism designer

²⁴This can be seen, for example, if a budget constraint applies to the set of feasible multidimensional social choices such that more of one desirable social choice implies less of another desirable social choice (e.g., bundles of goods). Assuming preferences are monotonic, each agent’s most-preferred amount of the good is the maximal feasible amount, however, the optimal decision involves them trading off each good, implying the maximal feasible amount is unlikely to be selected for either good. I address this problem further in Section 4.4.

²⁵Social choices may be random variables if, for example, agents have incomplete information, play mixed strategies or tremble, or outcomes are subject to moves of nature. If such random variables have a sample space with values not in $\max(c_j) \geq c \geq \min(c_j)$, then Proposition 2 may be violated. Examples include bilateral trade models of Chatterjee and Samuelson (1983) and Myerson and Satterthwaite (1983), the Battle of the Sexes Luce and Raiffa (1957) mixed strategy equilibrium, and the model of executive compensation presented in Bolton and Dewatripont (2004).

²⁶This approach to modeling the ‘error’ term may be considered intuitively appealing because the approach maintains the unit sum and non-negativity constraints on power whilst assigning the most power to the agent whose most-preferred social choice is nearest to the actual social choice.

knows that other family members will disregard their instructions if the instructions to the family members give them an incentive to do so. Thus, the mechanism designer must choose an equilibrium.

		Husband				Husband	
		Visit	No Visit			Visit	No Visit
Wife	Visit	1, 2, 2	0, 0, 0	Wife	Visit	0, 0, 0	0, 0, 0
	No Visit	0, 0, 0	0, 0, 0		No Visit	0, 0, 0	2, 1, 1
		Visit				No Visit	
		Mother				Mother	

Figure 3.1: Payoff matrix for the family’s fertility choice problem. Within cells, the payoffs for each agent are in the following order: Wife, Husband, Mother. Payoffs are expressed in utils.

To apply Proposition Proposition 15, one must define the set of feasible social choices and the mechanism designer. Assuming this game is the only mechanism for determining the family’s choice, the set of feasible social choices will consist of Visit Together and No Visit Together since both are pure strategy Nash Equilibria. Since social choices must be a number on the real number line, assign Visit Together a value of 1 and No Visit Together a value of 0. Thus, the set of feasible social choices which satisfies Supposition 1 of Proposition 2 is given by:²⁷

$$F = \{0, 1\}$$

Now suppose the wife is the mechanism designer. If so, 0, which is No Visit Together, is selected as the family choice. The power weights for each family member and the error are therefore given uniquely by:

$$\begin{aligned} \rho_{Wife} &= 1, \\ \rho_{Husband} &= \rho_{Mother} = 0, \text{ and} \\ \varepsilon &= 0. \end{aligned}$$

Now instead suppose that the husband or the mother is the mechanism designer. If so, 1, which is Visit Together, is selected as the family choice. Since both the husband’s and the mother’s most-preferred family choice is Visiting Together whilst the wife’s is not, the set of

²⁷The set satisfies Supposition 1 because the social choices are elements of the real number line that can be implemented as Nash Equilibria.

power weights and the error that satisfy Proposition 15 and Lemma 1 are given by:

$$\rho_{Wife} = 0,$$

$$\rho_{Husband} + \rho_{Mother} = 1, \text{ and}$$

$$\varepsilon = 0,$$

To generate an example where $\varepsilon \neq 0$, suppose that the husband, wife and mother ‘tremble’ (Selten, 1975) with some strictly positive probability by, for example, visiting the incorrect location by mistake or misunderstanding the mechanism designer’s instructions. It is, therefore, possible that the family does not coordinate, which is no family member’s most-preferred social choice ex-post. This outcome will be assigned a value of -1. Thus, regardless of which Nash equilibria is chosen to implement the family choice, it is now possible for the family choice to be -1. If -1 is the outcome, then the wife’s most-preferred choice, which is 0, is closest to -1. Therefore, in accordance with Lemma 1:

$$\rho_{Wife} = 1,$$

$$\rho_{Husband} = \rho_{Mother} = 0, \text{ and}$$

$$\varepsilon = -1.$$

3.3 Empirics: Implications and use with a binary treatment variable

I now turn to the empirical application of the power-weighted social choice function. In Section 3.3.1, I outline preliminaries, which consists of the set of equations that will be used to derive results in later sections and expressing the power-weighted social choice function in empirical notation. In Section 3.3.2, I present results for the robust interpretation of the coefficient of the proxy for power in social choice power regressions. In Section 3.3.3, I discuss deriving bounds on treatment effects and implications for the design of experiments. Finally, in Section 3.3.4, I address structural estimation with the power-weighted social choice function by developing a predictive model for power that satisfies the moment conditions for identification of the mean most-preferred choices of the agent of interest and the benchmark agent.

3.3.1 Preliminaries

Since the focus is the use of social choice power regressions, I first briefly outline the set-up for social choice power regressions. I then outline the set of equations that will be used with the power-weighted social choice function to recover social choice power regressions. First, suppose the effect, β_A , of the agent of interest, A , on social choices, $Y_{i,t}$, is to be analyzed using a dataset with observations of the social choices of many social groups, i , possibly across time, t , a binary treatment variable, $\tilde{P}_{i,A,t}$, as the proxy for the power, $P_{i,A,t}$, of the agent of interest, and other observables relevant to each group's social choices, $X_{i,t}$. I focus on the case where $X_{i,t}$ contains an intercept term only. Since binary treatment is generally considered to have occurred within the same time period, I drop the subscript t . The analysis is, therefore, conducted using a social choice power regression given by:

$$Y_i = \beta_0 + \beta_A \tilde{P}_{i,A} + e_i \quad (3.1)$$

where β_0 is the intercept term, e_i is the error term, and Y_i , β_A and $\tilde{P}_{i,A}$ are as defined above.

To recover the social choice power regression in Equation 3.1, the power-weighted social choice function in Lemma 1 will be used. Rewriting the power-weighted social choice function in terms of the variables in Equation 3.1 gives:

$$Y_i = \sum_j Y_{i,j} P_{i,j} + \varepsilon_i \quad (3.2)$$

where:

- i indexes social groups as in Equation 3.1 above, and $j = 1, 2, \dots, J$ indexes agents,
- Y_i is the social choice of group i ,

- $Y_{i,j}$ are agents most-preferred social choices, where $Y_{i,j} \in F_i \subseteq \mathbb{R}$ and F_i is the feasible set of social choices,
- $P_{i,j}$ are the power weights of each agent with $\sum_j P_{i,j} = 1$ and $P_{i,j} \geq 0$ for all i and j , and
- ε_i is term representing ‘errors’ in social choices which arise when the social choice is not between the minimum and maximum most-preferred social choices of the agents. That is, if:
 - if $Y_i < \min(Y_{i,j})$, $\varepsilon_i := Y_i - \min(Y_{i,j})$ and $\rho_{min} = 1$, where ρ_{min} is the power of agent j' and agent j' is the agent for which $Y_{i,j'} = \min(Y_{i,j})$,
 - if $Y_i > \max(Y_{i,j})$, $\varepsilon_i := Y_i - \max(Y_{i,j})$ and $\rho_{max} = 1$, where ρ_{max} is the power of agent j'' and agent j'' is the agent for which $Y_{i,j''} = \max(Y_{i,j})$,
 - otherwise, $\varepsilon_i := 0$.

Note that Equation 3.2 likely implies a correlated random coefficient model because accurate measurements of power are functions of agents’ most-preferred social choices. To see this, note that for all i , in Proposition 3.2, $P_{i,j}$ ’s are defined as the possibly non-unique solutions to the following system of equations:

$$\begin{aligned}
 Y_i &= \sum_j Y_{i,j} P_{i,j} \\
 \sum_j P_{i,j} &= 1 \\
 P_{i,j} &\geq 0 \text{ for all } j
 \end{aligned}$$

Thus, the set of solutions for $P_{i,j}$ depends on Y_i and $Y_{i,j}$, i.e. $P_{i,j} := f(Y_i, Y_{i,j})$. Since $P_{i,j}$ depends on $(Y_i, Y_{i,j})$, it will be assumed that the assumption required for OLS to identify the coefficients in Equation 3.2 does not hold.²⁸

I make the following assumptions to connect the power-weighted social choice function to social choice power regressions. First, I follow a common approach in the literature adopting social choice power regressions by supposing there is a benchmark agent, B ,²⁹ and assume that the power of all agents other than the agent of interest and the benchmark agent is zero,

²⁸Since I have not fully specified the equation that OLS will be applied to, I have not specified the exact assumption that must be violated for this to be true. For an example where the assumption appears to be violated, see Section 3.3.4. Note also that this does not apply to Equation 3.5.

²⁹Note that the benchmark agent could be a hypothetical agent. This is because, if one knew the most-preferred social choices of this hypothetical agent and the agent of interest, power could still be calculated.

i.e., $P_{i,j} = 0$ for $j \notin \{A, B\}$ so that:

$$Y_i = Y_{i,A}P_{i,A} + Y_{i,B}P_{i,B} + \varepsilon_{i,A-B} \quad (3.3)$$

where $\varepsilon_{i,A-B}$ is defined similarly to ε_i , except $\varepsilon_{i,A-B}$ is defined with respect to the agent of interest and benchmark agent rather than all agents. I will also assume that $\varepsilon_{i,A-B} = 0$ for all i , unless otherwise stated.

Second, since a binary variable is used as a proxy, power is a linear function of the proxy for power. Specifically:

$$P_{i,A} = B_0 + B_{\tilde{P}}\tilde{P}_{i,A} \quad (3.4)$$

where $B_0 = P_{i,A}(0)$, $B_{\tilde{P}} = P_{i,A}(1) - P_{i,A}(0)$, $P_{i,A}(0)$ is the value of $P_{i,A}$ when $\tilde{P}_{i,A} = 0$, and $P_{i,A}(1)$ is the value of $P_{i,A}$ when $\tilde{P}_{i,A} = 1$. Note that B_0 and $B_{\tilde{P}}$ are therefore random coefficients.³⁰

3.3.2 Interpreting results

In this section, I provide results for using β_A to make qualitative inferential statements³¹ about either the most-preferred social choices of the agent of interest or the effect of the proxy for power on the power of the agent of interest that do not depend on the underlying distribution of $(Y_i, Y_{i,A}, Y_{i,B}, P_{i,A}, \tilde{P}_{i,A})$ (a ‘robust interpretation’). To do so, I first recover Equation 3.2 given the preliminaries in Section 3.3.1. I then apply the results for robust interpretation to interpret the results AFL. The interpretations I draw using these results is contrary to the interpretations of the authors; using AFL’s assumptions and assumptions derived from statements made in AFL, I find that, rather than treatment disempowering wives, treatment may have empowered the majority of wives and disempowered a minority of wives.³²

First, to recover an equation with functional form equivalent to Equation 3.2,³³ simply substitute the unit sum constraint on power, $P_{i,B} = 1 - P_{i,A}$, and Equation 3.4 into Equation 3.3:

$$Y_i = Y_{i,B} + (Y_{i,A} - Y_{i,B})B_0 + (Y_{i,A} - Y_{i,B})B_{\tilde{P}}\tilde{P}_{i,A} = \beta_0 + \beta_A\tilde{P}_{i,A} + e_i \quad (3.5)$$

³⁰The random coefficients B_0 and $B_{\tilde{P}}$ in Equation 3.4 capture variables that affect power other than the proxy for power.

³¹The term ‘inference’ is not used in order to avoid confusion with the conventional use of the term ‘inference’ in econometrics, which refers to statistical inference. See Section 3.3.4 for results that could potentially be used for statistical inference.

³²In Appendix B.1, I also provide results based on adjustments to AFL’s assumptions I believe to be reasonable. After doing so, the interpretations become more complex. See Appendix B.1 for more detail.

³³Strictly speaking, because of the unit sum constraint, this is not the only form for social choice power regressions that can be derived. For example, the unit sum constraint need not be substituted into the equation, which would render $\beta_0 = \mathbb{E}[Y_{i,B}P_{i,A} + Y_{i,A}B_0]$ and $\beta_A = E[Y_{i,A}B_{\tilde{P}}]$. The correspondence between the parameters that are estimated and these different values for β_0 and β_A would be pinned down by the estimation procedure and the distribution of variables. Since $\tilde{P}_{i,A}$ is a binary treatment variable, it follows that the parameters expressed in Equation 3.5 are those that would be identified by OLS.

where $\beta_0 = \mathbb{E}[Y_{i,B} + (Y_{i,A} - Y_{i,B})B_0]$, $\beta_A = \mathbb{E}[(Y_{i,A} - Y_{i,B})B_{\tilde{P}}]$ and $e_i = Y_{i,B} + (Y_{i,A} - Y_{i,B})B_0 - \beta_0 + ((Y_{i,A} - Y_{i,B})B_{\tilde{P}} - \beta_A)\tilde{P}_{i,A}$. Given $\beta_A = \mathbb{E}[(Y_{i,A} - Y_{i,B})B_{\tilde{P}}]$, an accurate conclusion about either the sign of $\mathbb{E}[Y_{i,A} - Y_{i,B}]$ or the sign of $\mathbb{E}[B_{\tilde{P}}]$ is non-trivial because $Y_{i,A} - Y_{i,B}$ or $B_{\tilde{P}}$ could vary in such a manner that leads to incorrect conclusions.³⁴ I therefore suggest the following robust approach for inferring the sign of $\mathbb{E}[Y_{i,A} - Y_{i,B}]$ (or $\mathbb{E}[B_{\tilde{P}}]$ by substituting $B_{\tilde{P}}$ for $Y_{i,A} - Y_{i,B}$ and $Y_{i,A} - Y_{i,B}$ for $B_{\tilde{P}}$ in the Proposition).

Proposition 16. (Inferring the sign of $\mathbb{E}[Y_{i,A} - Y_{i,B}]$) Suppose:

- i. It is known that $\beta_A < 0$ or it is known that $\beta_A > 0$,
- ii. It is known that it could be that either $Y_{i,A} - Y_{i,B} > 0$ for all i or $Y_{i,A} - Y_{i,B} < 0$ for all i , but cannot be that $Y_{i,A} - Y_{i,B} > 0$ for some i and $Y_{i,A} - Y_{i,B} < 0$ for the remaining i , and
- iii. it is known that $B_{\tilde{P}} \geq 0$ for all i or it is known that $B_{\tilde{P}} \leq 0$ for all i ,

then the sign of $\mathbb{E}[Y_{i,A} - Y_{i,B}]$ can be inferred from β_A .

Proof: First note that:

$$\beta_A = \mathbb{E}[(Y_{i,A} - Y_{i,B})B_{\tilde{P}}] = \int (Y_{i,A} - Y_{i,B})B_{\tilde{P}} dF$$

If the signs of β_A and $B_{\tilde{P}}$ for all i are known, and it is known that either $Y_{i,A} - Y_{i,B} > 0$ for all i or $Y_{i,A} - Y_{i,B} < 0$ for all i , then each $Y_{i,A} - Y_{i,B}$ must have the sign that ensures all $(Y_{i,A} - Y_{i,B})B_{\tilde{P}}$ are of the same sign as β_A or are equal to zero. It then follows that the sign of $\mathbb{E}[Y_{i,A} - Y_{i,B}]$ is the same as the sign of each $Y_{i,A} - Y_{i,B}$.

Proposition 16 can be understood as follows. Since the distributions of both $Y_{i,A} - Y_{i,B}$ and $B_{\tilde{P}}$ are unknown and $\beta_A = \mathbb{E}[(Y_{i,A} - Y_{i,B})B_{\tilde{P}}]$, inferring the sign of $\mathbb{E}[Y_{i,A} - Y_{i,B}]$ from β_A may appear infeasible. However, even if the distributions are unknown, if the sign of $B_{\tilde{P}}$ is known and is the same over its entire distribution and the sign of $Y_{i,A} - Y_{i,B}$ is known to be the same over its distribution, then the sign of $Y_{i,A} - Y_{i,B}$ must be the such that $(Y_{i,A} - Y_{i,B})B_{\tilde{P}}$ has the same sign as β_A . Intuitively, given the effect of $\tilde{P}_{i,A}$ on Y_i (i.e., $(Y_{i,A} - Y_{i,B})B_{\tilde{P}}$) is decomposable into the product of the effect of $P_{i,A}$ on Y_i (i.e., $Y_{i,A} - Y_{i,B}$) and the effect of $\tilde{P}_{i,A}$ on $P_{i,A}$ (i.e., $B_{\tilde{P}}$), then given the sign of the effect of $\tilde{P}_{i,A}$ on Y_i and the sign of the effect of $\tilde{P}_{i,A}$ on $P_{i,A}$, the sign of the effect of $P_{i,A}$ on Y_i follows.

To apply Proposition 16, one should validate its assumptions. Given $\varepsilon_{i,A-B} = 0$ for all i , $\tilde{P}_{i,A}$ is a binary treatment variable and assuming OLS is used to estimate Equation 3.5, assumption i.

³⁴For example, suppose and $B_{\tilde{P}} \geq 0$ for all i and $\mathbb{E}[Y_{i,A} - Y_{i,B}] > 0$, however $Y_{i,A} - Y_{i,B} > 0$ for some i and $Y_{i,A} - Y_{i,B} < 0$ for the remaining i . If $B_{\tilde{P}}$ is small when $Y_{i,A} - Y_{i,B} > 0$ and large when $Y_{i,A} - Y_{i,B} < 0$, then $\beta_A < 0$. Thus, it would be incorrect to conclude $\mathbb{E}[Y_{i,A} - Y_{i,B}] < 0$ because $\beta_A < 0$ and $B_{\tilde{P}} \geq 0$ for all i .

is (approximately) given by the sign of the OLS estimate of the coefficient for $\tilde{P}_{i,A}$.³⁵ Given the most-preferred social choice functions of each agent are unknown, it may be difficult to validate assumption ii., however, one reasonable approach may be to apply (empirically accurate) theories that characterize the preferences of agents in order to justify (or refute) assumption ii., even if assumption ii. holds only for particular domains of the observables. A theory-based approach may also be used to justify assumption iii..³⁶ When doing so, the following may be useful, which relies on the characteristics of the (true) social choice function Y_i with respect to the proxy for power.³⁷

Proposition 17. (*Inferring the sign of $B_{\tilde{P}}$*) Suppose:

- i. either it is known that $\frac{\partial|Y_i - Y_{i,A}|}{\partial\tilde{P}_{i,A}} \leq 0$ for all i or it is known that $\frac{\partial|Y_i - Y_{i,A}|}{\partial\tilde{P}_{i,A}} \geq 0$ for all i , and
- ii. $\frac{\partial Y_{i,A}}{\partial\tilde{P}_{i,A}} = 0$ and $\frac{\partial Y_{i,B}}{\partial\tilde{P}_{i,A}} = 0$ for all i , and $Y_{i,A} \neq Y_{i,B}$ for all i ,

then the sign of $B_{\tilde{P}}$ is the same for all i and can be inferred from the assumptions given above.

Proof: Suppose $\varepsilon_{i,A-B} = 0$. Since $\varepsilon_{i,A-B} = 0$, $\min(Y_{i,A}, Y_{i,B}) \leq Y_i \leq \max(Y_{i,A}, Y_{i,B})$. Note also that since there are only two agents, power can be written as:

$$P_{i,A} = \frac{Y_i - Y_{i,B}}{Y_{i,A} - Y_{i,B}} = B_0 + B_{\tilde{P}}\tilde{P}_{i,A},$$

so that, given $\frac{\partial Y_{i,A}}{\partial\tilde{P}_{i,A}} = 0$ and $\frac{\partial Y_{i,B}}{\partial\tilde{P}_{i,A}} = 0$ for all i , $B_{\tilde{P}}$ can be written as:

$$B_{\tilde{P}} = \frac{\partial P_{i,A}}{\partial\tilde{P}_{i,A}} = \frac{\frac{\partial Y_i}{\partial\tilde{P}_{i,A}}}{Y_{i,A} - Y_{i,B}}.$$

Now, given $\min(Y_{i,A}, Y_{i,B}) \leq Y_i \leq \max(Y_{i,A}, Y_{i,B})$, if $Y_{i,A} > Y_{i,B}$, then $\frac{\partial|Y_i - Y_{i,A}|}{\partial\tilde{P}_{i,A}} \leq 0$ $\left(\frac{\partial|Y_i - Y_{i,A}|}{\partial\tilde{P}_{i,A}} \geq 0 \right)$ implies $\frac{\partial Y_i}{\partial\tilde{P}_{i,A}} \geq 0$ and, therefore, $B_{\tilde{P}} \geq 0$ ($B_{\tilde{P}} \leq 0$). If instead $Y_{i,A} < Y_{i,B}$, then

³⁵If $\varepsilon_{i,A-B} \neq 0$ for some i , it may be that the OLS estimator is not a \sqrt{N} -consistent estimator of β_A since it is not necessarily that $\mathbb{E}[\varepsilon_{i,A-B}|\tilde{P}_{i,A}] = 0$, even if a binary treatment variable is used. This could be because treatment affects not only power, $P_{i,A}$, but also the F -Pareto efficiency of the mechanism as captured by $\varepsilon_{i,A-B}$ (F -Pareto efficiency is Pareto efficiency determined on F , the set of feasible social choices). To see how in a simple (but perhaps extreme) example, suppose $\varepsilon_{i,A-B} \neq 0$ for all i so that $\beta_A = 0$, that treatment, $\tilde{P}_{i,A}$, has a non-zero average effect on the outcome, Y_i , and that $\tilde{P}_{i,A}$ does not affect agents' preferences, $Y_{i,A}$ and $Y_{i,B}$. If so, then it must be that $\mathbb{E}[\varepsilon_{i,A-B}|\tilde{P}_{i,A} = 1] \neq 0$ since the only way that $\tilde{P}_{i,A}$ affects $Y_{i,t}$ is through $\varepsilon_{i,A-B}$ (that is, $\tilde{P}_{i,A}$ affects the 'degree', as measured by $\varepsilon_{i,A-B}$, of F -Pareto efficiency of the interactions determining the social choice). Furthermore, since $\mathbb{E}[\varepsilon_{i,A-B}|\tilde{P}_{i,A} = 1] \neq 0$, the OLS estimator is an inconsistent estimator for $\beta_A = 0$.

³⁶It may also be that there is empirical evidence to support an assumption, however, given agents' most-preferred social choices and, therefore, power (by definition since agents' most-preferred social choices are not known) are often unknown, theory-based assumptions may be required. See Section 3.3.4 for an alternative approach where there is a validation dataset that contains agents' most-preferred social choices.

³⁷By (true) social choice functions, we are referring to the social choice function used in Supposition 1.

$\frac{\partial|Y_i-Y_{i,A}|}{\partial\tilde{P}_{i,A}} \leq 0$ $\left(\frac{\partial|Y_i-Y_{i,A}|}{\partial\tilde{P}_{i,A}} \geq 0 \right)$ implies $\frac{\partial Y_i}{\partial\tilde{P}_{i,A}} \leq 0$ and, therefore, $B_{\tilde{P}} \geq 0$ ($B_{\tilde{P}} \leq 0$). Since for $Y_{i,A} > Y_{i,B}$ or $Y_{i,A} < Y_{i,B}$ (and noting that $Y_{i,A} \neq Y_{i,B}$),³⁸ it follows that $B_{\tilde{P}} \geq 0$ ($B_{\tilde{P}} \leq 0$). Suppose $\varepsilon_{i,A-B} \neq 0$. If $\varepsilon_{i,A-B} \neq 0$, then $B_{\tilde{P}} = 0$ since either $P_{i,A} = 0$ or $P_{i,A} = 1$ regardless of the variation of $\tilde{P}_{i,A}$. Since for $\varepsilon_{i,A-B} = 0$ or $\varepsilon_{i,A-B} \neq 0$ it follows that $B_{\tilde{P}} \geq 0$ ($B_{\tilde{P}} \leq 0$), it follows that $B_{\tilde{P}} \geq 0$ ($B_{\tilde{P}} \leq 0$) for all i .

Since the argument for the case where $\varepsilon_{i,A-B} \neq 0$ is definitional (power is not sensitive to the proxy where $\varepsilon_{i,A-B} \neq 0$), I focus here on explaining the case for Proposition 17 where the social choice, Y_i , is always between the most-preferred social choices of the agent of interest and the benchmark agent (i.e., $\varepsilon_{i,A-B} = 0$). This case can be understood as a ‘tug-of-war’ between the agent of interest and the benchmark agent. $\frac{\partial|Y_i-Y_{i,A}|}{\partial\tilde{P}_{i,A}} \leq 0$ $\left(\frac{\partial|Y_i-Y_{i,A}|}{\partial\tilde{P}_{i,A}} \geq 0 \right)$ captures the idea that $\tilde{P}_{i,A}$ can be conceived as an action that pulls (pushes) the social choice closer to (further from) the most-preferred social choice of the agent of interest. If this is the case, and it is also assumed that $\tilde{P}_{i,A}$ is not an action that changes agents preference for winning the tug-of-war (i.e., $\frac{\partial Y_{i,A}}{\partial\tilde{P}_{i,A}} = 0$ and $\frac{\partial Y_{i,B}}{\partial\tilde{P}_{i,A}} = 0$ for all i) and that both agents prefer for themselves to win as indicated by a different ‘winning’ location in the tug-of-war (i.e., $Y_{i,A} \neq Y_{i,B}$), then $\tilde{P}_{i,A}$ must be an empowering (disempowering) action for the agent of interest, i.e., $B_{\tilde{P}} \geq 0$ ($B_{\tilde{P}} \leq 0$), when $\frac{\partial|Y_i-Y_{i,A}|}{\partial\tilde{P}_{i,A}} \leq 0$ $\left(\frac{\partial|Y_i-Y_{i,A}|}{\partial\tilde{P}_{i,A}} \geq 0 \right)$. This is because, given the center line for the game of tug-of-war (i.e. the social choice) is between the agents, it follows that $\tilde{P}_{i,A}$ is an action that always brings the agent of interest closer to (further from) winning, which is their most-preferred social choice.³⁹

To demonstrate the usefulness of these results, I now apply them to AFL with wives as the agent of interest and assuming $\varepsilon_{i,A-B} = 0$ for all couples in the sample.⁴⁰ To summarize, AFL use an experiment to study the effect of moral hazard on contraceptive use in households in Zambia in 2007. AFL’s experiment involved a control group in which wives individually received a voucher for free access to family planning services, which included free access to con-

³⁸If $Y_{i,A} = Y_{i,B}$, then there is not a unique solution for $P_{i,A}$. Rather, the solutions for satisfy $P_{i,A} \in [0, 1]$. For this case, since both Y_i and the bounds of $P_{i,A}$ are not sensitive to $\tilde{P}_{i,A}$, it may be intuitive to conclude $B_{\tilde{P}} = 0$. However, due to the complexities of dealing with non-unique solutions, I have not formally confirmed that this result follows.

³⁹For brevity, this explanation deals with the strict inequality case. That is, what is said in words corresponds to $\frac{\partial|Y_i-Y_{i,A}|}{\partial\tilde{P}_{i,A}} < 0$ $\left(\frac{\partial|Y_i-Y_{i,A}|}{\partial\tilde{P}_{i,A}} > 0 \right)$ and $B_{\tilde{P}} > 0$ ($B_{\tilde{P}} < 0$). To incorporate the weak inequality, positive statements can be changed to negative statements and the terms in brackets swapped with their alternatives outside the brackets.

⁴⁰This assumption might be considered valid for the following reasons. First, for couples assigned to the Individual treatment, the wife can essentially act as the mechanism designer by directly selecting her most-preferred option. Second, for couples assigned to the Couple treatment, it is perhaps reasonable to assume complete information about each other’s preferences and, if not, that the cost of communicating to confirm there is not a mutually non-harmful alternative that makes at least one partner better off among binary outcomes is so low as to ensure an F -inefficient outcome does not occur.

concealable contraceptives, ('Individual' treatment) and a treatment in which wives and husbands jointly received the voucher with the voucher handed to the husband ('Couple' treatment). In Figure 3.2 below, I present screenshot of the results for voucher redemption and concealable contraceptive use from AFL. In their analysis, AFL assign Couple treatment a value of 1 and Individual treatment a value of 0, so it seems reasonable to assume that $B_{\bar{p}} \leq 0$ for all participants (that is, being assigned to the Couple treatment disempowered all wives) since, as noted by AFL, wives in the Individual treatment could always choose to decide with their husband. Thus, consistent with the demographic characteristics provided by AFL that Zambian men want 0.8 more children than their wives (Salem, Mandal, and Richey, 2004), which might be taken to imply Zambian men would have a lower preference for contraception than women, applying Proposition 16 to the AFL estimates for β_A in Columns 1 and 2 of Figure 3.2, in which $\beta_A < 0$, implies $\mathbb{E}[Y_{i,A} - Y_{i,B}] \geq 0$. Alternatively, for similar reasons given above about the relative preferences of Zambian men and women for children, if one takes $Y_{i,A} - Y_{i,B} \geq 0$ as known and applies Proposition 16, then the conclusion is $B_{\bar{p}} \leq 0$.

Interpreting the result in this way, however, is potentially misleading given the results for 'Responders' and 'Nonresponders'. AFL divide their analysis into 'Responders' and 'Nonresponders' based on inferences about the relative fertility preferences of husbands and wives in their study. Responders are households in which the wife does not want to have a child in the next two years, in which the wife believes their husband's ideal number of children is larger than the households current number of children or in which the wife believes the husband wants more children than the household currently has,⁴¹ and in which the wife believes the husband has a higher maximum, ideal or minimum number of desired children than she does.⁴² Since AFL suggest an aspect of their classification approach is to "capture as many possible conflicts as possible" in the Responder subsample,⁴³ it may be reasonable to assume that in the Responder sample $Y_{i,A} - Y_{i,B} > 0$ for all i , whilst in Nonresponder households this is not the case so that among Nonresponders $Y_{i,A} - Y_{i,B} \leq 0$ for all i .⁴⁴

⁴¹Whilst these two conditions sound identical, each condition is a separate field in AFL's code, which, to the best of my knowledge, refers to different questions in the survey associated with their experiment.

⁴²This classification is based on the code in AFL's replication package. It is closest to the description of the Responder group in AFL's Table 2, however, it includes households in which the wife believes the husband has a higher minimum or maximum, not only ideal, number of children than she does. As best I can tell, it does not exactly match AFL's description across pages 2223-224, particularly footnote 27, since the husband's stated preferences are not used.

⁴³AFL do acknowledge that there may be measurement error in this classification approach. AFL suggest that this classification approach is likely to underestimate the number of potential responders. I agree, however, for reasons different to those given by AFL. See footnote 44 for details.

⁴⁴In particular, AFL suggest in footnote 27 of their paper (and implement in their code) that, in addition to the wife's beliefs about whether the husband desires more children, households in which (the wife believes) the husband has a higher ideal or maximum (or minimum) number of children than she does should be included as Responders. However, by including this condition using 'and', the number of potential conflicts that are captured must be weakly less than the number without doing so. Therefore, it cannot be that "as many possible conflicts as possible" are captured. If this is the goal, 'or' should be used instead of 'and' since using 'or' would weakly capture more conflicts. For example, there may be households in which the wife believes the husband desires more children

TABLE 2—EFFECT OF PRIVATE INFORMATION TREATMENT ON HOUSEHOLDS

	All women				Responders		Nonresponder	
	Voucher redeemed (1)	Received injectable (2)	Birth in next year IV 2nd stage (3)	Used voucher IV 1st stage (4)	Voucher redeemed (5)	Received injectable (6)	Voucher redeemed (7)	Received injectable (8)
<i>Panel A. Without controls</i>								
Assigned to Couple treatment	-0.101*** (0.036)	-0.060** (0.030)		-0.269*** (0.096)	-0.159** (0.076)	-0.136** (0.064)	-0.070 (0.043)	-0.029 (0.035)
Used voucher			-1.369** (0.614)					
Average treatment effect (ATE)			-0.268					
Average treatment on the treated (ATT)			-0.468					
<i>Panel B. With controls</i>								
Assigned to Couple treatment	-0.098*** (0.037)	-0.058* (0.030)		-0.244** (0.106)	-0.182** (0.083)	-0.108 (0.068)	-0.072 (0.044)	-0.046 (0.035)
Used voucher			-1.656** (0.681)					
Average treatment effect (ATE)			-0.325					
Average treatment on the treated (ATT)			-0.583					
Observations	749	749	706	706	169	169	536	536
Mean of outcome variable among individual treatment	0.529	0.243	0.054	0.541	0.632	0.284	0.496	0.223
Estimator	OLS	OLS	Probit	Probit	OLS	OLS	OLS	OLS

Notes: A responder is defined as a women who doesn't want a child in the next two years who believes her husband wants to have more children than they currently have and who also believes her husband wants more children than she does. Nonresponders didn't satisfy these requirements and didn't have missing information on the relevant variables. Controls include: age, husband's age, education, husband's education, number of children, wife's ideal number of children, husband's ideal number of children, using injectables at baseline, using pill at baseline, using any hormonal contraceptive at baseline, wife's monthly income, husband's monthly income, difference in desired fertility of couple, wife knows when she is most fertile, woman's age > 40, time since last birth, difference between husband's and wife's total number of children, and compound indicators. Missing values for controls were replaced with a zero and dummy variables for missing values were included in the regression. A voucher was "redeemed" if there is a record of a voucher use by a woman in the study at the Chiapata Clinic. Bootstrapped biprobit estimation was used to determine Birth in Next Year, with assignment to treatment as an IV for take-up of family planning services. The ATE and ATT were determined using Stata's binormal command to calculate predicted linear indices.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Figure 3.2: Screenshot of Table 2 from AFL.

Given this, application of Proposition 16 to the results for Responders leads to the conclusion that $B_{\bar{p}} < 0$ as above. However, application of Proposition 16 for Nonresponders leads to the somewhat surprising conclusion that $B_{\bar{p}} \geq 0$ for all i .⁴⁵ That is, contrary to intuitions about the effect of assignment to the Couple treatment on $B_{\bar{p}}$ (or inferences based on intuitions and information about $Y_{i,A} - Y_{i,B}$ in the population or overall sample), assignment to the Couple treatment (weakly) *empowered* women who either had similar fertility preferences to their husband or preferred higher fertility than their husband.⁴⁶ Thus, given Nonresponders account for 77% of the sample and the negative effect for the entire sample is partially attributable to wives with similar or higher fertility preferences than their husbands who were empowered by receiving the Couple treatment, it may be unwarranted to attribute the negative effect for the entire sample as AFL do; that is, as “suggestive evidence of a trade-off between privately

than the household currently has yet the wife believes the husband desires less children than she does, whilst the husband nonetheless would still prefer the wife was not currently on (concealable) contraception and the wife would rather be on concealable contraception for timing related reasons. Whilst using ‘or’ instead of ‘and’ may also weakly increase the the number of households misclassified as Responders, if the wife’s desire to be pregnant in the next two years is a good approximation of her preference for contraception, then many of the misclassifications should be screened out by this additional condition when ‘and’ is replaced with ‘or’. To support this hypothesis, I present a pattern of results in Appendix B.1 that suggests using ‘or’ instead of ‘and’ may be more accurate. In Appendix B.1, I also present results for average treatment effects where ‘or’ is used instead of ‘and’. For voucher use, the average treatment effect estimates for Responders and Nonresponders both increase but remain negative, whilst, similar to the results presented in AFL, the effect is statistically significant in the Responder sample and statistically insignificant in the Nonresponder sample. For injectable use, the average treatment effect estimates for Responders and Nonresponders both increase, however the effect for Nonresponders becomes slightly positive and statistically insignificant, whilst the effect for Responders remains negative and statistically significant. Whilst this may seem problematic for the argument that follows, see footnote 45, Section 3.3.3 and Appendix B.1 for why that is not the case.

⁴⁵Some may suggest that this conclusion is not warranted or is exaggerated because the results in the Nonresponder sample are statistically insignificant. However, given the information available, information related to the magnitude of $B_{\bar{p}}$, such as statistical significance, cannot be deduced. For example, it could be that $Y_{i,A} - Y_{i,B}$ is small, not $B_{\bar{p}}$, which is what is driving the statistically insignificant results. To test this, I conduct a robustness test in Appendix B.1 where I shift the equality sign when comparing the wives beliefs about the relative maximum, ideal and minimum number of children between her and her husband, and I shift the equality sign when comparing whether the wife believes the husband wants more children. Similar results to those presented in Table 2 of AFL follow for voucher use, however, the effect on injectable use becomes positive and is still statistically insignificant. However, as will be shown in Section 3.3.3 below, the average treatment effects estimated in AFL are likely upper bounds on their respective β_{AS} , indicating that the true β_A is likely overestimated, and therefore even more negative, than AFL find. Using the results of Ashraf, Field, and Leight (2013) where a treatment that only affected preferences through the household either receiving a voucher or not, which was applied to an almost identical sample as AFL, it appears the effect on injectable usage could be overestimated by approximately somewhere between 0.073 and 0.105, where each end of this range is statistically significant in Table 2 of Ashraf, Field, and Leight (2013) (see footnote 53 in Section 3.3.3 for a discussion of the appropriateness of using these numbers directly as an indicator of overestimation of β_{AS}). Given that the family planning voucher must have been used in order to receive the injectable, this range may also serve as a lower bound on the overestimation of the effect on using the voucher. Combining these indicators of the overestimation of β_{AS} with the fact that statistical tests of the sign of parameters should be one-sided rather than two-sided, and using the parameter estimates and standard errors reported by AFL in Figure 3.2, the average treatment effects for Nonresponders are negative and statistically significant. See Appendix B.1 for more detail.

⁴⁶This result is perhaps not as surprising as it seems if considered from the perspective of a wife with higher fertility preferences than her husband. This is because the opportunity to take the concealable contraception does not give her any opportunity to pursue her objective of having more children. In contrast, the opportunity to discuss contraception with her husband may, for example, provide her an opportunity to convince him to have more children.

improving a women’s set of choices, which may result in contraceptive use that could improve welfare for herself. . . , and lowering the conjugal value of the marriage” or evidence that “giving women greater opportunity to conceal birth control brought . . . [women] closer to their short-term fertility goals.” Rather, based on the evidence in the AFL, such a conclusion was perhaps warranted for the 23% of women in the Responder subsample. This conclusion may be further supported by results presented in the next section, which indicate β_A is plausibly overestimated by the average treatment effect in AFL given AFL’s experimental design.

3.3.3 Bounding treatment effects and testing assumptions through experimental design

In some experiments, both preferences and power are shocked by a binary treatment (see, for example, AFL; Gazeaud, Khan, Mvukiyeh, and Sterck, 2023).^{47, 48, 49} Whilst this is often acknowledged as a limitation, it is sometimes remarked that the validity of the experimental results relies, when intending to shock power, on maintaining the difference in preferences (e.g. AFL) or, when intending to shock preferences, there being no net effect on power (Augsburg, Malde, Olorenshaw, and Wahhaj, 2023). In this section, I show that, when shocking power under the aforementioned assumptions, experimental validity also relies on there being no effect on the preferences of the benchmark agent and, using AFL as an example, show how to use this result to generate an upper or lower bound on β_A . I also outline why a 2x2 factorial experimental design can be used to jointly test the assumptions that differences in preferences and net effects on power are zero. Note that, with a slight abuse of terminology, I use the term ‘preferences’ interchangeably with ‘most-preferred social choices’ throughout.

First, suppose only power is intended to be shocked, however, preferences are also shocked. Let $Z_i \in \{0, 1\}$ represent the binary treatment, which can be seen as simultaneously shocking two different binary variables; a binary variable that affects the power of the agent of interest, $\tilde{P}_{i,A} \in \{0, 1\}$, and a binary variable that affects preferences,⁵⁰ $D_i \in \{0, 1\}$, such that:

$$(\tilde{P}_{i,A}, D_i) = \begin{cases} (1, 1), & Z_i = 1 \\ (0, 0) & Z_i = 0 \end{cases}$$

⁴⁷Gazeaud, Khan, Mvukiyeh, and Sterck (2023) provide women with cash and gender sensitive financial training. The gender sensitive financial training “aimed at stimulating women’s agency.” Therefore, it may be reasonable to suggest the cash grant shocked preferences and the gender sensitive financial training shocked power.

⁴⁸Note that, by definition, shocking preferences may shock power in the framework presented in Section 3.2.

⁴⁹Throughout this paper, it is assumed that either the average treatment effect is identified by OLS (for example, due to full compliance, or satisfaction of the known support and monotonicity assumptions), or the estimates are intent to treat estimates. Extension to other applied settings is an area for future research.

⁵⁰I do not yet specify whose preferences are affected by D_i since treatment of preferences may be asymmetric as in AFL. See footnote 51 for more detail on AFL specifically.

Using Equation 3.3 and the unit sum constraint for power, and assuming $\varepsilon_{i,A-B} = 0$ for all i , the treatment effect of Z_i is therefore given by:

$$Y_i(1, 1) - Y_i(0, 0) = Y_{i,B}(1) - Y_{i,B}(0) + \Delta Y_{i,A-B}(1)P_{i,A}(1, 1) - \Delta Y_{i,A-B}(0)P_{i,A}(0, 0)$$

where $\Delta Y_{i,A-B}(\cdot) = Y_{i,A}(\cdot) - Y_{i,B}(\cdot)$, $Y_{i,A}(\cdot)$ and $Y_{i,B}(\cdot)$ are only functions of D_i and $P_{i,A}(\cdot, \cdot)$ is a function of $(\tilde{P}_{i,A}, D_i)$. Suppose, however, that it is the treatment effect of $\tilde{P}_{i,A}$ with no manipulation of D_i , i.e. $D_i = 0$, that is of interest. The treatment effect in this case is given by:

$$Y_i(1, 0) - Y_i(0, 0) = \Delta Y_{i,A-B}(0)(P_{i,A}(1, 0) - P_{i,A}(0, 0))$$

The difference between the two treatments effects can then be written as:

$$Y_{i,B}(1) - Y_{i,B}(0) + \Delta Y_{i,A-B}(1)(P_{i,A}(1, 1) - P_{i,A}(1, 0)) + (\Delta Y_{i,A-B}(1) - \Delta Y_{i,A-B}(0))P_{i,A}(1, 0) \quad (3.6)$$

From Equation 3.6 above, the difference between treatment effects depends on the difference in preferences of the benchmark agent across the preference treatments, $Y_{i,B}(1) - Y_{i,B}(0)$, the difference in differences in preferences across preference treatments, $\Delta Y_{i,A-B}(1) - \Delta Y_{i,A-B}(0)$, and differences in power across treatments, $P_{i,A}(1, 1) - P_{i,A}(1, 0)$. Thus, if $Y_{i,B}(1) \neq Y_{i,B}(0)$, even if the difference in preferences is maintained across preference treatments, $\Delta Y_{i,A-B}(1) = \Delta Y_{i,A-B}(0)$, and power is not affected by preference treatment, $P_{i,A}(1, 1) = P_{i,A}(1, 0)$, the (average) treatment effect when both preferences and power are shocked is not necessarily identical to the (average) treatment effect (β_A) when only power is shocked at $D_i = 0$.

Intuitively, this result can be understood as follows. By shocking power, power is redistributed among the two agents from a fixed, finite amount of power (i.e. like a budget) as per Power Scarcity (Assumption 4 in Section 3.2). However, by redistributing power and simultaneously shocking preferences, one must not only account for the effect of redistributing power, which is captured by differences in preferences between agents, but also the effect of shocking preferences in a non-unitary entity (such as a household). Since, in this case, the non-unitary entity can be conceptualized as a tug-of-war between two agents (see Section 3.3.2), shocking preferences can be seen as shocking the starting positions of the agents in the tug-of-war, which can be decomposed into a relative and absolute effect on preferences, and a power effect. The relative effect may move the starting positions such that the agents are closer to or further from each other, which is captured by changes in the differences in preferences between agents, $\Delta Y_{i,A-B}(1) - \Delta Y_{i,A-B}(0)$. The absolute effect, however, changes the position of the entire game of tug-of-war, which, given the relative effect, can be captured by noting the change in preferences of one of the agents, for example, $Y_{i,B}(1) - Y_{i,B}(0)$. The power effect, $P_{i,A}(1, 1) - P_{i,A}(1, 0)$, captures the effect of moving the starting positions of the game on each agent's ability to pull (or push), which, for example, using the tug-of-war analogy, is akin to

the change in starting positions changing the terrain on which the tug-of-war is played (e.g, the slope of the ground or type of surface). By only arguing that the difference in preferences remains unchanged and that power is unaffected, which is equivalent to suggesting the relative effect and power effects are zero, the absolute effect is not addressed.

Given this result, it is possible to derive the average treatment effect of Z_i as a bound on the average treatment effect of $\tilde{P}_{i,A}$, which corresponds to β_A . I provide an example in Lemma 2 below.

Lemma 2. (A bound on the average treatment effect of $\tilde{P}_{i,A}$, β_A) Suppose $\Delta Y_{i,A-B}(1) = \Delta Y_{i,A-B}(0)$ and $P_{i,A}(1, 1) = P_{i,A}(1, 0)$, then, if $\mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)] > (<) 0$, then $\mathbb{E}[Y_i(1, 1) - Y_i(0, 0)] > (<) \mathbb{E}[Y_i(1, 0) - Y_i(0, 0)] = \beta_A$

Proof: Given $\Delta Y_{i,A-B}(1) = \Delta Y_{i,A-B}(0)$ and $P_{i,A}(1, 1) = P_{i,A}(1, 0)$, then by Equation 3.6, $Y_i(1, 1) - Y_i(0, 0) - (Y_i(1, 0) - Y_i(0, 0)) = Y_{i,B}(1) - Y_{i,B}(0)$. Given $\mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)] > (<) 0$, it then follows that $\mathbb{E}[Y_i(1, 1) - Y_i(0, 0)] > (<) \mathbb{E}[Y_i(1, 0) - Y_i(0, 0)]$.

I now apply this result to AFL to show that the effect of secrecy on power in AFL may be overestimated by the average treatment effects in AFL, which, given the interpretations outlined in Section 3.3.2, also implies the degree to which treatment disempowered Responders and empowered Nonresponders is underestimated. To see this, note that AFL shock both preferences and power by providing a voucher for concealable contraceptives and the opportunity for secrecy (i.e. moral hazard) to the wife.⁵¹ Further suppose $\Delta Y_{i,A-B}(1) = \Delta Y_{i,A-B}(0)$ (which is mentioned by AFL in their Discussion section)⁵² and $P_{i,A}(1, 1) = P_{i,A}(1, 0)$. Assuming the voucher increased the attractiveness of the concealable contraceptives for the husband so that $\mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)] > 0$,⁵³ from Lemma 2 it follows that the treatment effect in AFL may be

⁵¹Since the voucher is offered across treatments, it may seem that the shock to preferences is the same across Individual and Couple treatments, i.e. $D_i = 1$ always. However, this is only the case for the wife. For the husband, $D_i = 0$ in the Individual treatment and $D_i = 1$ in the Couple treatment, which leads to the same result as that presented above. This issue is explicitly acknowledged by AFL in their Discussion section as "informational asymmetries within couples regarding the ease of accessing concealable contraception."

⁵²Due to the asymmetric treatment with the voucher, this is unlikely to be true if one believes the voucher affects husbands' preferences because the wives' preferences remain unaffected by treatment whilst the husbands do not. Under this alternative assumption $\Delta Y_{i,A-B}(1) - \Delta Y_{i,A-B}(0) = -(Y_{i,B}(1) - Y_{i,B}(0))$ so that $Y_i(1, 1) - Y_i(0, 0) - (Y_i(1, 0) - Y_i(0, 0)) = (Y_{i,B}(1) - Y_{i,B}(0))(1 - P(1, 0))$, from which similar results follow if instead it is assumed $Y_{i,B}(1) - Y_{i,B}(0) > 0$ for all i .

⁵³Whilst it may be intuitive that $\mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)] > 0$, conclusions with respect to the statistical significance of β_A will rely on the magnitude of $\mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)]$ and effect on the standard error of the estimates. Fortunately, there is a companion paper to AFL, Ashraf, Field, and Leight (2013), that may be helpful in this regard. Ashraf, Field, and Leight (2013) implement a similar treatment to AFL in an almost identical sample, however, the household receives a voucher or does not (handed to the wife in the presence of the husband if treated). In Table 2 of their paper, Ashraf, Field, and Leight (2013) provide two estimates of the average treatment effect on reported usage of injectables over the past two years (so not exactly matching the outcome in AFL, which is usage of injectables due to redemption of the voucher) corresponding to different subsamples; 0.073 and 0.105. Now, if it is assumed that the husband has complete control of the household decision, as AFL appear to imply ("[t]he Couple treatment, by essentially giving husbands veto power over contraceptives provided throughout the study, approximates the spousal consent rules governing many family planning services offered through public and private

larger than the effect of secrecy alone (i.e., a shock to the proxy for power alone), which corresponds to β_A .

I close this section by suggesting an experimental design and statistics for falsifying the joint conjecture that differences in preferences and power are unaffected by preference treatments.⁵⁴ The statistics are given in Lemma 3 below.

Lemma 3. *Suppose $\Delta Y_{i,A-B}(1) = \Delta Y_{i,A-B}(0)$, and $P_{i,A}(1, 1) = P_{i,A}(1, 0)$ and $P_{i,A}(0, 1) = P_{i,A}(0, 0)$, then $\mathbb{E}[Y_i(0, 1) - Y_i(0, 0)] = \mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)]$ and $\mathbb{E}[Y_i(1, 1) - Y_i(1, 0) - Y_i(0, 1) - Y_i(0, 0)] = 0$*

Proof: Given $\Delta Y_{i,A-B}(1) = \Delta Y_{i,A-B}(0)$ and $P_{i,A}(0, 1) = P_{i,A}(0, 0)$, it follows that:

$$Y_i(0, 1) - Y_i(0, 0) = Y_{i,B}(1) - Y_{i,B}(0) + \Delta Y_{i,A-B}(1)P_{i,A}(0, 1) - \Delta Y_{i,A-B}(0)P_{i,A}(0, 0) = Y_{i,B}(1) - Y_{i,B}(0)$$

from which $\mathbb{E}[Y_i(0, 1) - Y_i(0, 0)] = \mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)]$ follows. Given, furthermore, $P_{i,A}(1, 1) = P_{i,A}(1, 0)$, then:

$$Y_i(1, 1) - Y_i(0, 0) - (Y_i(1, 0) - Y_i(0, 0)) = Y_i(0, 1) - Y_i(0, 0),$$

from which $\mathbb{E}[Y_i(1, 1) - Y_i(1, 0) - Y_i(0, 1) - Y_i(0, 0)] = 0$ follows.

This result implies that the conjecture that power and differences in preferences are unaffected by preference-related treatment can be tested in a 2x2 factorial experimental design with shocks to power and preferences separately, or where only preferences are shocked.⁵⁵ Furthermore, the result can be understood as follows. If power and differences in preferences are unaffected by shocks to preferences (i.e. the power and relative effect are zero), then differences between the effect of shocking power and preferences and the effect of shocking power must be, using the tug-of-war analogy, attributable only to the shift in the game of tug-of-war (i.e the absolute effect on household preferences as measured by the difference in preference of one of the agent). Given, however, the power and relative effects are zero, this absolute effect is

clinics in much of the developing world") since veto power over a binary decision implies the ability to determine that decision, then the average treatment effects in Ashraf, Field, and Leight (2013) can be taken as approximations of the average treatment effects of the voucher on husbands' preferences, $\mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)]$. See Appendix B.1 for results and robustness tests that are adjusted with respect to these estimates. When combined with the fact that statistical significance with respect to claims about the sign of the effects should be assessed using a one-sided, not two-sided, test, the results for Nonresponders generally become statistically significant at the 1% level under AFL's assumptions.

⁵⁴This test may also be useful for testing an area for future research mentioned in Gazeaud, Khan, Mvukiyehe, and Sterck (2023), who, in an experiment with a treatment with a similar preference-power structure as AFL, note that one of the treatment effects they observe may be due to different impacts on husbands preferences, resulting from how wives represent their privately received information about a cash grant, or the effect on the power dynamic between the husband and wife.

⁵⁵Interestingly, if power and differences in preferences are unaffected by preference-related treatment, then Lemma 3 also implies that treatment need only be applied to either the agent of interest or the benchmark agent to estimate the average effect on households.

entirely captured by only shocking preferences. Thus, the effect of shocking both preferences and power can be decomposed into the individual effects of shocking power and preferences separately.

3.3.4 Structural estimation and measuring power for identification

The model presented for social choices in terms of power (i.e., Equation 3.3), has the appealing properties of a structural interpretation and a simple functional form implying a linear random coefficients model. Assuming one is interested in statistics related to agents' preferences⁵⁶ and following the random coefficients literature, it may therefore seem desirable and feasible to estimate the value, rather than form arguments about the sign, of the mean differences in the most-preferred social choices of the agent of interest and benchmark agent. However, two potential challenges present themselves in attempting to do so. First, the model may be a *correlated*, linear random coefficients model (see Section 3.3.1). Second, given agents' most-preferred social choices are unobserved, power is also unobserved and, therefore, a measurement of power is required that permits identification of mean difference in the most-preferred social choices.

To address this problem, I suggest an approach that involves using a validation dataset to measure power such that the statistical properties for identification of the mean most-preferred social choices are satisfied.⁵⁷ To do so, I adapt an approach from the literature that uses predictive models as measurements for latent variables in validation datasets where the latent variables become observable (see, for example, Knox, Lucas, and Cho, 2022; Yang, Adomavicius, Burtch, and Ren, 2018). To show this, I begin with a set-up akin to that in the measurement error literature⁵⁸ (see, for example, Schennach, 2022) where, rather than Equation 3.4, the relationship between power and the proxy for power is given by:⁵⁹

$$P_{i,A} = \hat{P}_{i,A} + \varepsilon_i$$

and $\hat{P}_{i,A}$ is a model for power. Rather than constructing $\hat{P}_{i,A}$ to most accurately measure $P_{i,A}$ by constructing $\hat{P}_{i,A}$ as a predictive model for $P_{i,A}$, the parameters of the model $\hat{P}_{i,A}$ are derived

⁵⁶Given the structure of Equation 3.3, one may instead be interested in statistics related to agents' power. The methods in this section could also be applied to recover the expected value of agents' power.

⁵⁷For approaches to measurement error and the use of proxies without validation datasets, see Schennach (2022). Note that I proceed with the approach outlined in this section as I believe it is relatively more plausible than the approaches to measurement error and the use of proxies outlined in Schennach (2022). It does, however, require a validation dataset, which is often difficult to obtain.

⁵⁸Whilst power can be approximated or proxied, it cannot be measured per se without knowledge of most-preferred social choices. Furthermore, it cannot be measured prior to the occurrence of social choices since the solution to the system of equations from Section 3.3.1 depend on social choices (despite power appearing on the right-hand side of the social choice equation and, therefore, appearing to cause or explain social choices).

⁵⁹I use $\hat{P}_{i,A}$ instead of $\tilde{P}_{i,A}$ to indicate that this proxy is not the same as that used in Sections 3.3.2 and 3.3.3.

such that the OLS moment conditions necessary for identification in the model:

$$Y_i = \beta_0 + \beta_1 \hat{P}_{i,A} + e_i$$

are satisfied, where $\beta_0 = \mathbb{E}[Y_{i,B}]$, $\beta_1 = \mathbb{E}[Y_{i,A} - Y_{i,B}]$ and $e_i = Y_{i,B} - \beta_0 + (Y_{i,A} - Y_{i,B} - \beta_1)\hat{P}_{i,A} + (Y_{i,A} - Y_{i,B})\varepsilon_i$. Specifically, the parameters of the model $\hat{P}_{i,A}$ must satisfy:

$$\mathbb{E}[e_i] = 0, \text{ and}$$

$$\mathbb{E}[\hat{P}_{i,A}e_i] = 0.^{60}$$

Assuming the distribution of e_i and $\hat{P}_{i,A}$ are identical in and out of the validation dataset, the model, $\hat{P}_{i,A}$, developed for measuring $P_{i,A}$ can be used to identify $\mathbb{E}[Y_{i,B}]$ and $\mathbb{E}[Y_{i,A} - Y_{i,B}]$ outside the validation dataset.

To demonstrate the performance of this approach relative to existing approaches, I use the AFL dataset sourced from Ashraf, Field, and Lee (2019). To do so, I infer wives and husbands most-preferred voucher use choice and develop an approximation for power using only the binary treatment indicator. I infer husbands and wives most-preferred voucher use by using the Responder and Nonresponder split; for Responders, wives prefer contraceptive use, and therefore voucher use, and husbands do not, and vice versa in the Nonresponder group. The approximation for power is given by:

$$P_{i,A} = \gamma_0 + \gamma_1 Z_i + \varepsilon_i = \hat{P}_{i,A} + \varepsilon_i$$

where $\hat{P}_{i,A} = \gamma_0 + \gamma_1 Z_i$. To find γ_0 and γ_1 such that $\mathbb{E}[e_i] = 0$ and $\mathbb{E}[\hat{P}_{i,A,t}e_i] = 0$, I solve for γ_0 and γ_1 that satisfy the zero conditional mean assumptions.⁶¹

$$\mathbb{E}[e_i | (1, Z_i = 0)] = 0, \text{ and}$$

$$\mathbb{E}[e_i | (1, Z_i = 1)] = 0.$$

These conditional moment conditions imply:

$$\gamma_0 = \frac{\mathbb{E}[Y_i | (1, Z_i = 0)] - \mathbb{E}[Y_{i,B}]}{\mathbb{E}[Y_{i,A} - Y_{i,B}]}$$

$$\gamma_1 = \frac{\mathbb{E}[Y_i | (1, Z_i = 1)] - \mathbb{E}[Y_i | (1, Z_i = 0)]}{\mathbb{E}[Y_{i,A} - Y_{i,B}]}$$

⁶¹Note that, despite the conditions resembling exogeneity conditions, these conditions are imposed, not assumed, in the model fitted in the validation dataset much like moment conditions are imposed in the generalized method of moments.

To test the effectiveness of this approach, I run 10,000 simulations in which I split the AFL dataset into a validation set and a test set. In the validation set, I estimate γ_0 and γ_1 as:

$$\hat{\gamma}_{0,ID} = \frac{\frac{1}{N_0} \sum Y_i(0) - \frac{1}{N} \sum Y_{i,B}}{\frac{1}{N} \sum (Y_{i,A} - Y_{i,B})}$$

$$\hat{\gamma}_{1,ID} = \frac{\frac{1}{N_1} \sum Y_i(1) - \frac{1}{N_0} \sum Y_i(0)}{\frac{1}{N} \sum (Y_{i,A} - Y_{i,B})}$$

where " $\hat{\gamma}$ " indicates a fitted parameter, ID indicates the approach for estimating γ 's is that required for identification of the parameters of interest, N is the number of observations in the validation dataset, N_0 is the number the number of observations in the validation dataset for which $Z_i = 0$, $Y_i(0)$ are social choices for which $Z_i = 0$, N_1 is the number the number of observations in the validation dataset for which $Z_i = 1$ and $Y_i(1)$ are social choices for which $Z_i = 1$. I then use $\hat{P}_{i,A} = \hat{\gamma}_{0,ID} + \hat{\gamma}_{1,ID}Z_i$ to approximate power in the test set. I measure performance in the test set by the difference between the test set sample values of $\mathbb{E}[Y_{i,B}]$ and $\mathbb{E}[Y_{i,A} - Y_{i,B}]$, denoted \bar{Y}_B and $\bar{Y}_A - \bar{Y}_B$, respectively, and the constrained OLS estimates, $0 \leq \hat{\beta}_{0,ID} \leq 1$ and $-1 \leq \hat{\beta}_{1,ID} \leq 1$, of the parameters in:⁶²

$$Y_i = \beta_{0,ID} + \beta_{1,ID}\hat{P}_{i,A} + e_i,$$

respectively. I compare the performance of this approach to the following approaches. First is the naïve approach of assuming $\hat{P}_{i,A,t} = Z_i$ ⁶³ and interpreting the OLS estimates of $\hat{\beta}_{0,N}$ and $\hat{\beta}_{1,N}$ of the parameters in:

$$Y_i = \beta_{0,N} + \beta_{1,N}\hat{P}_{i,A} + e_i,$$

as estimates of $\mathbb{E}[Y_{i,B}]$ and $\mathbb{E}[Y_{i,A} - Y_{i,B}]$. The second approach follows a similar approach to Fong and Tyler (2021) by using OLS to fit a reduced-form, predictive model (the 'prediction-based approach) directly to:

$$P_{i,A} = \gamma_0 + \gamma_1 Z_i + \varepsilon_i$$

then using $\hat{P}_{i,A} = \hat{\gamma}_{0,OLS} + \hat{\gamma}_{1,OLS}Z_i$ as the measure of power in the test set. I then apply constrained OLS to estimate $0 \leq \hat{\beta}_{0,P} \leq 1$ and $-1 \leq \hat{\beta}_{1,P} \leq 1$ in:

$$Y_i = \beta_{0,P} + \beta_{1,P}\hat{P}_{i,A} + e_i,$$

In the final approach, which may be consider akin to an 'oracle' in terms of measurement, I use

⁶²If this approach is implemented, many parameter estimates are outside the known bounds on $\mathbb{E}[Y_{i,B}]$ and $\mathbb{E}[Y_{i,A} - Y_{i,B}]$. The issue appears to be driven by simulations in which $\hat{\gamma}_1 \approx 0$, which is, therefore, leading to problems in estimation akin to those encountered with the use of weak instruments. Constrained OLS is used to apply these bounds.

⁶³Given the results of AFL appear to indicate that the majority of wives were empowered by treatment, $\hat{P}_{i,A} = Z_i$ is the appropriate assumption since $P_{i,A}$ is monotonically increasing in $\hat{P}_{i,A}$.

the true values of $P_{i,A}$ and apply OLS to estimate $\hat{\beta}_{0,O}$ and $\hat{\beta}_{1,O}$ in:

$$Y_i = \beta_{0,O} + \beta_{1,O}P_{i,A} + e_i.$$

I use three different validation-test set splits. In the first, the test set is simply the validation set. In the second, the validation set and test set are drawn from the AFL dataset with replacement and are of size 50% of the AFL dataset. In the third, the validation set and test set are drawn without replacement with size 50% of the AFL dataset, respectively.

The results of the simulations can be seen in Tables 3.1 and 3.2 below. As can be seen, the approximation approach performs well relative to the naïve and prediction-based approaches. As expected, the approximation performs perfectly when the test set is the validation set, whilst the naïve and prediction-based approaches do not. Notably, the oracle does not perform perfectly when the validation set is the test set, nor for any version of the test set. This is driven by a small correlation between the random coefficients and power, which violates the identification assumptions for OLS (see, for example, Heckman and Vytlačil, 1998). Furthermore, when the test set is not the validation set, the mean of the differences are close to 0 for the approximation approach and oracle, and, as expected, non-zero for the naïve and prediction-based approaches. However, whilst the RMSEs for the approximation approach are still much better than the prediction-based approach, the RMSEs for the approximation approach are only slightly better than the RMSEs for the naïve approach. This is largely driven by the relatively high variances of $\hat{\beta}_{0,ID}$ and $\hat{\beta}_{1,ID}$. The relatively high variances of $\hat{\beta}_{0,ID}$ and $\hat{\beta}_{1,ID}$ are attributable to differences between the appropriate $\hat{P}_{i,A}$ in the test and validation set and is exacerbated by simulations in which $\hat{\gamma}_1 \approx 0$, which is generating a problem akin to the weak instruments problem.

Test set	$\bar{Y}_B - \hat{\beta}_{0,ID}$	$\bar{Y}_B - \hat{\beta}_{0,N}$	$\bar{Y}_B - \hat{\beta}_{0,P}$	$\bar{Y}_B - \hat{\beta}_{0,O}$
Validation set	0.000 (0.000)	-0.231 (0.235)	-0.075 (0.450)	0.001 (0.026)
Without replacement	-0.006 (0.198)	-0.230 (0.235)	-0.113 (0.468)	0.007 (0.025)
With replacement	0.017 (0.316)	-0.230 (0.233)	-0.052 (0.648)	0.007 (0.019)

Table 3.1: Mean (RMSE) of differences between \bar{Y}_B and estimates of $\mathbb{E}[Y_{i,B}]$ under various approaches to estimating β_0 .

Test set	$\bar{Y}_A - \bar{Y}_B - \hat{\beta}_{1,ID}$	$\bar{Y}_A - \bar{Y}_B - \hat{\beta}_{1,N}$	$\bar{Y}_A - \bar{Y}_B - \hat{\beta}_{1,P}$	$\bar{Y}_A - \bar{Y}_B - \hat{\beta}_{1,O}$
Validation set	0.000 (0.000, 1.000)	0.425 (0.430, 0.979)	0.455 (0.638, 0.689)	-0.001 (0.005, 1.000)
Without replacement	0.005 (0.381, 0.956)	0.423 (0.429, 0.976)	0.417 (0.617, 0.664)	-0.001 (0.005, 1.000)
With replacement	-0.042 (0.166, 0.995)	0.424 (0.426, 0.998)	0.478 (0.648, 0.729)	-0.001 (0.003, 1.000)

Table 3.2: Mean (RMSE, Accuracy) of differences between $\bar{Y}_A - \bar{Y}_B$ and estimates of $\mathbb{E}[Y_{i,A} - Y_{i,B}]$ under various approaches to estimating β_1 . Accuracy measures the proportion of simulations in $\bar{Y}_A - \bar{Y}_B$ estimates of $\mathbb{E}[Y_{i,A} - Y_{i,B}]$ achieved through estimating β_1 are of the same sign.

3.4 Conclusion, discussion and suggestions for future research

In this paper, I develop and apply a framework for modeling social choices as power-weighted functions of agents' most-preferred social choices. I show that such a framework, whilst borderline simplistic, has intuitive micro-foundations, can be usefully (and consequentially) applied to the interpretation of results, may assist in the design of experiments and the derivation of bounds on the results of imperfectly designed experiments, and can be applied structurally, either given appropriate measurements of power or to develop such measurements. Nonetheless, the framework has some weaknesses, some of which I address below and others of which I leave as areas for future research. First, however, I address the question; why this simple (almost simplistic) framework and not the many other existing frameworks (such as the collective bargaining models referred to in AFL)?

To address this question, I compare the framework (the 'Power weights' framework) presented in this paper to other common power-based frameworks. The comparison is summarized in Table 3.3 below. The common power-based frameworks appear in the columns of Table 3.3 and the criteria against which the comparison is made appears along the rows of Table 3.3. As can be seen, the power framework compares well with other frameworks across most, but not all criteria. Essentially, the power weights framework presented in this paper has advantages over other commonly used frameworks in relation to social choice power regressions because social choices are expressed as linear functions of power with coefficients that are easily interpretable. Power indices, for example, typically do not permit the expression of the social choice as a function of the power index. Approaches that apply Pareto weights (see, for example, Chiappori and Mazzocco, 2017), whilst permitting expression of social choices in terms of Pareto weights, may have solutions in which the social choice is non-linear in the Pareto weights due to the functional form of agents' utility functions. Even if social choices are linear in power, approaches reliant on Pareto weights and Nash Bargaining weights (Kalai, 1977), whose solution for objects is in the same units as the transfers (if can also be seen as social choices), have coefficients of Pareto or bargaining weights that are functions of utility functions, cost functions, boundary conditions or threat points depending on the application. This complicates interpretation relative to the power-based framework in this paper because such constructs are, arguably, relatively more difficult to define, measure and discuss than the most-preferred social choices of the agents. This is demonstrated in the literature that uses social choice power regressions where effects are explained in terms of agents preferences for the social choice (i.e. most preferred social choices), not how happy agents are with the outcome (i.e. utility functions), nor the limits (i.e. boundary conditions) or outside options (i.e., threat points) of agents.

	Shapley-Shubik index	Pareto weights	Nash Bargaining weights	Power weights
Social choices are linear functions of power?	No	Unusual	It depends	Yes
Interpretability of coefficients	-	Difficult	Difficult	Easy
Affected by utility function assumptions?	Yes	Yes	Yes	No
Unique solution?	Yes	Not always	Not always	Not always
Multidimensional social choices	Yes	Yes	Yes	No
Random social choices	Yes	No	No	No
Assumes 'efficiency'	No	Yes	Yes	Yes

Table 3.3: Comparison of power-based approaches for explaining social choices

Nonetheless, existing power-based frameworks may have advantages over the ‘Power weights’ framework in some applications, particularly with respect to one relative weaknesses that can be seen from Table 3.3 and another which all frameworks appear to share. These are that the framework only applies to unidimensional, non-random social choices (see Supposition 1) and relies on a condition akin to Pareto efficiency (i.e., $\varepsilon_i = 0$ for all i , which is implied by $\max(c_j) \geq c \geq \min(c_j)$). However, in realistic environments, such as those characterized by incomplete information and trembling and where multiple social choices are bundled together, such an assumption is unlikely to hold. Exploring the implications of this problem for the use of the power-based framework presented in this paper is a useful area for future research.⁶⁴

Other areas for future research include, but are not necessarily limited to, addressing the uniqueness of power weights, reconciling differences in power weights across different social choices, developing better approximation methods for power, considering the application of the framework beyond two agents, and the extension of results to observational studies and the use of instrumental variables. Addressing the non-uniqueness of the power weights will assist with implementing the method for more than two agents (particularly given most social choices are likely determined by more than two agents, despite the simplicity of the model if only two agents is assumed), may be resolved by combining multiple measures or choices (which may also reconcile differences in power weights to some extent) to eliminate some power weight solutions, or in combination with observations of the phenomena that imply some agent has more power than others. Better approximation methods for power are likely important for structural application of the method, particularly given the poor RSME performance without constraints on the coefficients, and seem feasible given the simplicity of the method applied in this paper. Finally, despite the paper being partially motivated by the use of social choice power regressions in observational studies, I focused almost entirely on experiments. Given the additional empirical challenges posed by observational studies and in other applied settings, this is also an important area for future research.

⁶⁴In particular, where multiple social choices are bundled together, a multidimensional power matrix or function may appropriate.

Chapter 4

Firm, investor and manager objectives, and firm behavior

Abstract

Over the last decade, there has been considerable research across economics, finance, management and law investigating the relationship between firm behavior and either the objective functions of firms, or the objective functions of investors and managers. We provide a critical review of this literature. In doing so, we provide a taxonomy of maximization problems from the literature in order to improve the clarity of definitions. We also find that, despite the progress in the literature on exploring the differences between the firm behaviors implied by objective functions from the firm behaviors implied by (short-term) profit maximization, the differences between other objective functions remain largely theoretically unexplored and empirically untested. Therefore, despite the leaps forward taken in this literature over the last decade, there appears to be considerable opportunity for future research in this area.

4.1 Introduction

Over the last decade, the environmental and social ('ES'), and economic impacts of firms have been under considerable scrutiny. Private actors, regulators and academics alike have investigated the competitive threats and scale benefits posed by industry concentration, cross-ownership, mergers and acquisitions, and common ownership (Australian Federal Government, 2021; Cavenaile, Celik, and Tian, 2021; FTC, 2018, 2023; Schmalz, 2018, 2021; United States House of Representatives, 2020). Firms' ES externalities, spillovers, and activities have also been widely investigated, such as firms' greenhouse gas emissions, provision of potentially harmful products, workplace health and safety record, and corporate political activities (see, for example, Azar, Duro, Kadach, and Ormazabal, 2021; Bertrand, Bombardini, Fisman, Hackinen, and Trebbi, 2021; Bertrand, Bombardini, Fisman, Trebbi, and Yegen, 2023; Chen, Dong, and Lin, 2020; Dyck, Lins, Roth, and Wagner, 2019). To explain and judge the observed firm behavior and impacts, those involved often opine on the objective of the firm or the objectives of agents with a plausibly influential degree of control of firm behavior; typically, those who are shareholders or managers of the firm.

In this survey, we argue that, in aggregate, the theory and evidence presented in the recent literature may only allow one to reject firms, investors or managers acting according to a short-term profit maximization objective. To do so, we construct a taxonomy of maximization problems based on theories of the firm and the objective functions of firms, shareholders and managers. We then assess whether recent theoretical papers explore the differences between the firm behavior implied by different maximization problems and find that they only explore the difference between their objective of interest and (short-term) profit maximization. Preliminary results from an ongoing survey of the empirical literature confirm a similar result with respect to empirical papers. We find that, despite the steps forward taken by the literature over the past decade, the challenge of classifying firms, investors or managers as acting according to some objective function or maximization problem remains largely an open problem (the 'classification problem').¹

In addition to arguing that the classification problem remains unsolved, we make the following contributions to the literature. First, we provide a taxonomy of maximization problems based on various theories of the firm and the objectives of firms, investors and managers, which may

¹We would like to emphasize the difference between answering the classification problem for firms, and organizational economics and organizational studies; it could be easily asked, if one is interested in explaining firm behavior, why not directly investigate and model the interactions between agents that lead to particular firm choices? Why treat the firm as if it has an objective or solves a maximization problem? Whilst proceeding according to the former question is no doubt an interesting and useful endeavor, solving the classification problem may be considered a useful exercise given the common practice of assuming a maximization problem for firms when modeling firm behavior in some research areas, such as in the industrial organization literature. Furthermore, doing so may be considered interesting, at least to some, given the challenge it poses and pragmatic given the difficulty of obtaining data on and modeling the interactions between the sometimes vast number of agents that leads to firm choices.

be useful to others in solving the classification problem. Second, relative to the existing literature on firm, investor and manager objectives, we discuss constrained maximization problems rather than focusing only on objective functions. Whilst constrained maximization problems are certainly nothing new, expanding the discussion beyond objective functions is important. For example, doing so highlights potentially important features of some theories that appear to often go unnoticed, such as Friedman (1962, 1970, 2002) suggesting ethical constraints in profit maximization, and may lead to theoretical results that are interesting or empirically relevant.² Finally, we believe, to the best of our knowledge, that we are the first to address the problem of comparing such a broad set of types of maximization problems or objective functions.³ This will be shown below, and can be seen, for example, in the recent survey articles of Schmalz (2018, 2021), Gerardi, Lowry, and Schenone (2024), Gillan, Koch, and Starks (2021) and DesJardine, Zhang, and Shi (2023) where papers generally consider two, and at most three, objective functions.

The rest of the paper proceeds as follows. In Section 4.2, we provide a taxonomy of maximization problems for firms. In Section 4.3, we assess whether recent theory compares firm behavior under different maximization problems. In Section 4.4, we conclude, discuss the limitations of our results and suggest areas for future research.

²In Section 4.4, we demonstrate two such results related to the existence of non-profit maximizing firms and the existence of a firm-level maximization problem.

³By types of maximization problems or objective functions, we mean maximization problems or objective functions with unique incentive parameters in their objective functions or unique sets of constraints as opposed to unique values for the incentive parameters or constraints.

4.2 Taxonomy of maximization problems

In this section, we provide a brief taxonomy of maximization problems based on prominent theories and objectives that have been considered as explaining the behavior or suggested for guiding the behavior of firms, investors and managers across economics, finance, management and law.^{4,5} The theories and objectives we cover are profit maximization, common ownership, social responsibility and stakeholder theory, drawing on both normative and positive versions of these theories.⁶ We approach the construction of the taxonomy as follows. First, we focus on those maximization problems from theories that have both recently been widely discussed in the academic literature and have a substantial underlying body of empirical literature.⁷ Second, for each theory, we define different maximization problems as a unique combination of an objective function and a set of constraints. We identify unique objective functions by identifying the set of payoffs that are explicitly given a non-zero discount factor in the objective function. We identify unique sets of constraints based on the terms used to describe the constraints. Where a theory that is prominent in the literature is proposed without a complete maximization problem, which includes an objective function and a set of constraints, we do our best to propose a complete maximization problem based on the content of the theory. Finally, if a maximization problem or objective function is established through an instrumental argument based on an appeal to an underlying maximization problem or objective function, we categorize such maximization problems or objective functions based on the underlying maximization problem or objective function.⁸

We begin with profit maximization. We provide two forms of profit maximization; short-term profit maximization and constrained, long-term profit maximization. Each form differs in

⁴When the same theory appears to be defined differently across the literature, we refer to the original sources and leading academics for those theories. This helps reduce the number of alternative definitions that must be considered. For example, Miles (2017) finds 593 different definitions of stakeholder theory.

⁵We are concerned with explaining firm behavior using a maximization problem rather than explaining firm structure or modeling firm behavior with firm structure. Thus, whilst we draw some maximization problems from theories of the firm, we are not concerned with outlining entire theories of the firm, which often involve describing or explaining the structure of the firm in addition to the behavior of the firm. For an insightful essay on theories of the firm, see Gibbons (2005).

⁶By 'positive theories', we mean both those theories that are descriptive and those based on inferences from theories of the firm and its external environment.

⁷We do not claim to cover all theories and objectives that have been proposed for the firms, investors and managers, nor even those that have been prominent at some point in time. However, at various points in the footnotes we reference other theories that we do not cover in-depth that may be of interest to the reader. We also provide an outline of maximization problems for theories not covered in this section that we encountered during our review in Appendix C.1, with a brief discussion of their relationship to the theories discussed in this section. These maximization problems include financial wealth maximization (better known as shareholder wealth maximization), long-term, broad, financial wealth common ownership, universal ownership, team production theory, and corporate purpose.

⁸We do not, however, seek to outline the basis of these maximization problems in moral or ethical theories. For examples of such exercises, see the list of moral theories suggested as a basis for stakeholder theory in Dmytriiev, Freeman, and Hörisch (2021).

terms of its objective function and constraints.⁹ Under short-term profit maximization ('STP'), only the profits generated in a relatively short amount of time, say one year, matter. Under long-term profit maximization ('LTP'), the entire future stream of profits¹⁰ is taken into account. Mathematically, the objective functions for firm i under each form of profit maximization, denoted φ_{STP} and φ_{LTP} ,¹¹ can be represented as:

$$\varphi_{STP} = \pi_{1,1}$$

$$\varphi_{LTP} = \sum_t \delta_t \pi_{1,t}$$

where $\pi_{j,t}$ are the payoffs to stakeholder group¹² j ¹³ in period t , shareholders are assumed to be the stakeholder group for which $j = 1$, $\pi_{1,t}$ represents profits in period t , δ_t is the discount factor applied to profits in period t , and $\delta_1 = 1$.

We suggest the following constraints over firm actions for each form of profit maximization, where the vector of actions for firm i is denoted $a_i := a \in \mathbb{R}^N$ and N is the number of distinct actions in the set of actions.¹⁴ For short-term profit maximization, we suggest participation constraints for each stakeholder group and production technology constraints. Participation constraints for each stakeholder group are of two types. The first are unconditional participation constraints. Participation constraints are unconditional if they must be satisfied regardless of whether the firm's choice of action requires the participation of a stakeholder group. For profit maximization, we assume only shareholders have an unconditional participation constraint. The second are conditional participation constraints. Conditional participation constraints only require participation by stakeholders when the stakeholder is necessary for the execution of the firm action at the desired level. That is, the participation constraint of the stakeholder group only applies for a particular subset of firm actions.¹⁵ To denote these par-

⁹A related objective function, which we discuss further in Appendix C.1, is financial wealth maximization. Financial wealth maximization, also known as shareholder wealth maximization, refers to the maximization of 'firm-value'. Firm-value, a common term in the finance literature, is defined as the present value of all of a firm's financial cash flows, not only profit to shareholders.

¹⁰To be clear, we are referring to the actual financial payoffs to shareholders, sometimes also referred to as free cash flows to equity. Throughout the paper, our focus is on actual payoffs, which generally includes cash flows, as opposed to, for example, accounting-based measures of some payoffs.

¹¹Note that, throughout the paper, objective functions will be denoted $\varphi_{Obj,i} := \varphi_{Obj}$ where Obj indexes the type of objective function and i is dropped for brevity.

¹²We focus on groups because doing so appears to be convention of this literature. It may, however, sometimes be more appropriate to focus on agents. We acknowledge that at times this use of notation may seem awkward, particularly when we enumerate stakeholder groups for stakeholder theory. However, it seemed most natural to begin the section.

¹³Whilst the index j may seem unnecessary at this point, in the constraints below there will be more than one stakeholder group.

¹⁴For the remainder of the paper, we generally drop the subscript i for brevity.

¹⁵It may seem unclear why these constraints are necessary. First, it will allow us to highlight an important difference between maximization problems based on stakeholder theory and other maximization problems. Second,

participation constraints, let $\tilde{\pi}_j$ represent the payoff used by stakeholder group j to assess their participation,¹⁶ $w_j \geq 0$ represent the stakeholder group's outside option and $A_{j,cp}$ represent the set of actions for which the participation of stakeholder group j is necessary. The unconditional participation constraint for shareholders is therefore given by $\tilde{\pi}_1 \geq w_1$, where $j = 1$ for shareholders. The conditional participation constraints for the remaining stakeholders are given by $\tilde{\pi}_j \geq w_j \mathbb{1}\{a \in A_{j,cp}\} - \infty(1 - \mathbb{1}_{a \in A_{j,cp}})$ for all $j \neq 1$, where the indicator function, $\mathbb{1}\{a \in A_{j,cp}\}$, determines whether a stakeholder group's payoff must be greater than their outside option, w_j , or can take any value as their payoff need only be greater than $-\infty$.^{17, 18} Production technology constraints, also known as the production possibility set, specify the relationship between inputs into, or factors of, the production process, collectively denoted F , and firm actions. Let $A_t(F)$ denote the set of technologically possible actions that can be taken given F .¹⁹

For constrained, long-term profit maximization, we suggest two further constraints; legal constraints and shared ethical constraints. Legal constraints are those constraints imposed by governments on the actions of the firm. Shared ethical constraints are the constraints imposed by shared ethical norms on firms' actions. To denote these constraints, let A_l denote the set of legally permissible actions for actions a and A_e denote the set of actions for actions a consistent with shared ethical norms. Thus, the legal and shared ethical constraints are given by $a \in A_l$ and $a \in A_e$, respectively.²⁰ Given these objectives and constraints, we suggest the follow maximization problems for short-term profit maximization and constrained, long-term

such constraints are arguably positively accurate for some firm actions. See the takeover example and reference in footnote 18.

¹⁶We allow the stakeholder payoffs used in participation constraints and stakeholder payoffs used in the objective functions to be different. This simplifies the exposition by not requiring us to ensure the payoffs suggested for stakeholders in the objective function are also used in the participation constraints. In actual problems, this may be required.

¹⁷Technically, when $a \in A_{j,cp}$, $\infty(1 - \mathbb{1}_{a \in A_{j,cp}}) = \infty \times 0$, which is undefined mathematically. For our purposes in the conditional participation constraints, we define it as 0.

¹⁸As a simple example, consider takeover offers and take the approval, or disapproval, of a takeover offer as the firm action $a \in \{0, 1\} \subset \mathbb{R}$. In takeovers, directors and executive management often must be involved for operational reasons, and, under profit maximization as presented below, the proposal often must be approved by shareholders (it is also the case that this could be a legal requirement in some jurisdictions and so there may be some overlap with legal constraints). The participation of other groups, such as employees, suppliers and customers, in executing a is, however, not necessarily required under profit maximization or under the law in some jurisdictions (satisfying such participation constraints could form part of the shared ethical constraints that, as we discuss further below, Friedman (1970) does not elaborate upon, however, suppose this is not the case for the example). Therefore, directors, executive management and shareholders must have their outside options satisfied, whilst other groups, such as employees, suppliers and customers, would be stakeholder groups whose payoffs could be arbitrarily below their outside option. For a real life example resembling this situation, see Bebchuk, Kastiel, and Toniolo (2023) for an outline of the effects of Elon Musk's takeover of Twitter on Twitter's stakeholders.

¹⁹Often $A_t(F)$ is a singleton so that $A_t(F)$ is a (single valued) function, which assumes that for any given set of inputs there is only one action the firm can take. However, we include the case where $A_t(F)$ may not be a singleton for generality. Furthermore, conventionally, F usually includes Labour (' L ') or Capital (' K '). We, however, remain intentionally vague about what specifically counts as a factor or production as it is not our focus.

²⁰For brevity, we drop the subscript i on the sets of permissible actions, i.e. the A 's, in each constraint. The constraints may or may not be firm-specific.

profit maximization, respectively:

$$\begin{aligned} \max_a \quad & \varphi_{STP} \\ \text{s.t.} \quad & \tilde{\pi}_1 \geq w_1, \\ & \tilde{\pi}_j \geq w_j \mathbb{1}\{a \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a \in A_{j,cp}\}) \text{ for all } j \neq 1, \\ & a \in A_t(F). \end{aligned}$$

$$\begin{aligned} \max_a \quad & \varphi_{LTP} \\ \text{s.t.} \quad & \tilde{\pi}_1 \geq w_1, \\ & \tilde{\pi}_j \geq w_j \mathbb{1}\{a \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a \in A_{j,cp}\}) \text{ for all } j \neq 1, \\ & a \in A_t(F), \\ & a \in A_l, \\ & a \in A_e. \end{aligned}$$

We justify our representation of each form of profit maximization separately. First, we believe that our representation of short-term profit maximization is an accurate representation of the optimization problem from early, neoclassical, positive economic theory which argued that in competitive markets firms must maximize profits in order to exist and included participation constraints and production technology constraints of the kinds presented (for a recent example, see Fleurbaey and Ponthière, 2023). We also believe the maximization problem for short-term profit maximization is important to include for two further reasons. First, it adequately captures the workhorse model that continues to be used extensively to generate many of the positive theories of firm behavior in economics and finance. Second, it is, arguably, the form of profit maximization that generates the firm behavior that is opposed by the proponents of other theories.²¹

Second, we believe our representation of constrained, long-term profit maximization is an accurate representation based on the normative argument of Friedman (1970) and various positive theories (see, for example, (Hart, 1979; Leland, 1974). The argument of Friedman (1970) about the responsibility of managers to shareholders in corporations, whom Friedman (1970) considered to be the owners of corporations, is summarized by the following quote; "[t]hat responsibility is to conduct the business in accordance with their[, the owners'] desires, which generally will be to make as much money as possible while conforming to the basic rules of the society, both those embodied in law and those embodied in ethical custom." Elsewhere,

²¹In stakeholder theory, see Dmytriyev, Freeman, and Hörisch (2021). In corporate social responsibility, see Smith and Rönnegard (2016). In constrained, long-term profit maximization, often, however, under other names such as enlightened shareholder theory, see, for example, Ho (2010), and in his example on serving local communities and the usefulness of adopting the "cloak of social responsibility", see, perhaps surprisingly, Friedman (1970).

Friedman (1970) uses an example in discussing what "may well be in the long run interest of a corporation." Taken together (and ignoring the reference to shareholder desires, which, as pointed out by Hart and Zingales (2017), may well be beyond profits), these quotes indicate that firms should optimize some function of profits over time, subject to constraints derived from the law and shared ethical norms.²² A theory of the firm and its external environment justifying the maximization of a discounted stream of future profits can also be found in Leland (1974) and Hart (1979).

We acknowledge, however, two potential challenges to the maximization problems presented above. First, it may be that other combinations of objectives and constraints are reasonable. For example, it may be that for some agents the long-term profit maximization objective is combined only with participation constraints. We do not oppose such combinations; we have simply provided our best understanding of the prominent representations in the literature, which we believe also captures the full set of objective functions and constraints attributed to profit maximization.

Second, given its lack of emphasis or development,²³ and given the profit-maximization-focused shareholder primacy of Friedman (1970) is often implicitly represented as morally or ethically limited,²⁴ the inclusion of shared ethical constraints may seem somewhat surprising. It should be noted, however, that, drawing on the first edition of his book, *Capitalism and Freedom* (Friedman, 1962), Friedman (1970) suggests that corporations "staying within the rules of the game" includes engaging "in open and free competition without deception or fraud." Whilst not necessarily suggesting anything beyond the law (as the quotation could be entirely covered by the law), evidence supporting that 'custom' be interpreted in line with its conventional definition as shared cultural norms can be found in Friedman's use of the term in *Capitalism and Freedom*. Furthermore, Friedman (2002) elsewhere suggests that participants, which presumably includes the shareholders of corporations, in a competitive market "obey the law of the land and ... live according to his lights."²⁵ Thus, it would seem that, at least according to Friedman's

²²A similar view can also be found in Hayek (1969).

²³We speculate, but leave as an interesting area for future research, that this may be for two reasons. First, classic liberals, or libertarians, such as Friedman, may be considered to have a relative higher tendency than others to leave ethical questions to the individual (see footnote 26) and ethical customs to the polity. Therefore, they may not have been as interested in developing such constraints themselves beyond their initial insistence on individual freedom, civic process, and democratic process in a manner that adequately limits the concentration of power. Second, historically, significant areas of economics can be quite heavily utilitarian or welfarist by utilizing (necessarily) imperfect models that focus almost entirely on preferences over a restricted set of objects (profits, money, products, etc) to justify greater government intervention and power. This seems to put a large part of economics, Friedman's own field, philosophically in opposition to his classic liberal position and the idea of ethical constraints. This is because, under utilitarianism, what is ethical is simply that which maximizes utility. Therefore, some in economics may have been less likely to develop Friedman's idea of ethical constraints but may have been relatively more comfortable adopting the objective of profit maximization.

²⁴This representation is implied by the criticism of Friedman's supposed assumption of the separability of money-making and profit. See, for example, Freeman, Wicks, and Parmar (2004).

²⁵The Merriam-Webster (2024) definition of living according to one's lights is to live "according to one's idea of

own works, not only are shared ethical constraints not necessarily empty, there may be scope to include personal ethical constraints and norms in the maximization problems presented above.²⁶

It should also be noted that, under profit maximization, we include those firm objectives that may not be equivalent to profit maximization but are justified by reference to either profit maximization or profit maximization and the external environment. This is because such theories, being justified on the basis of profit maximization, are, therefore, reducible to profit maximization (although the constraints may differ), which, for the purposes of characterizing firm behavior, we believe should not be distinguished from profit maximization. The objectives that are justified by reference to profit maximization include enlightened shareholder value (Ho, 2010), strategic CSR (Carroll, 1999), and instrumental stakeholder theory ((Donaldson and Preston, 1995)), and, depending on one's interpretation, may include recent work on "growing the pie" and corporate purpose by Edmans (2020). Objectives that may be justified by reference to profit maximization and the external environment includes those that arise due to the strategic use of delegation (see, for example, Aggarwal and Samwick, 1999; Fershtman and Judd, 1987; Fumas, 1992; Sklivas, 1987) and repeated interactions that lead to collusive firm behavior (Aghion and Bolton, 1987; Green and Porter, 1984).²⁷

We now build on profit maximization in two ways. First, we outline two maximization problems for common ownership, which differ in their objective functions. In the first, which we call short-term, intra-industry common ownership ('STIICO'), weight is given only to a firm's competitors. In the second, which we call long term, broad common ownership ('LTBCO'), weight is given to every firm in which a shareholder has rights to profits (often referred to as cash flow rights) and some power over the firm. The objective functions for intra-industry common ownership and broad common ownership are therefore given by:

$$\begin{aligned}\varphi_{STIICO} &= \varphi_{STP} + \sum_{j \in INTRA} \lambda_j \varphi_{STP,j} \\ \varphi_{LTBCO} &= \varphi_{LTP} + \sum_{j \in INTRA} \lambda_j \varphi_{LTP,j} + \sum_{k \in VINTER} \lambda_k \varphi_{LTP,k} + \sum_{l \in HINTER} \lambda_l \varphi_{LTP,l}\end{aligned}$$

where *INTRA* is the set of firms in the same industry as the firm, *VINTER* is the set of firms with vertical supply chain relationships with the firm, *HINTER* are horizontally related firms

what is right", which clearly is intended to have ethical content.

²⁶As further evidence, Friedman (2002) elsewhere suggests that "a major aim of the liberal is to leave the ethical problem for the individual to wrestle with." It should also be noted that Friedman's argument applies to the "desires" of principals of organizations, which, in corporations, are only "generally" profits and, therefore, not necessarily exclusively restricted to profits.

²⁷These objectives are not attributed to the firm, however, given they are the objectives by which managers make firm decisions, they are the objectives that characterize firm behavior at a relatively more superficial level.

(i.e., the set of firms not in *INTRA* or *VINTER*), and $\lambda \geq 0$ are the profit weights assigned to other firms (see, for example, Backus, Conlon, and Sinkinson, 2019).²⁸

For common ownership, the only constraints we suggest are participation constraints and production technology constraints. Thus, the maximization problem for each form of common ownership is given by:

$$\begin{aligned} \max_a \quad & \varphi_{STHCO} \\ \text{s.t.} \quad & \tilde{\pi}_1 \geq w_1, \\ & \tilde{\pi}_j \geq w_j \mathbb{1}\{a \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a \in A_{j,cp}\}) \text{ for all } j \neq 1 \\ & a \in A_t(F). \end{aligned}$$

$$\begin{aligned} \max_a \quad & \varphi_{LTBCO} \\ \text{s.t.} \quad & \tilde{\pi}_1 \geq w_1, \\ & \tilde{\pi}_j \geq w_j \mathbb{1}\{a \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a \in A_{j,cp}\}) \text{ for all } j \neq 1 \\ & a \in A_t(F). \end{aligned}$$

We justify these representations on two different bases.²⁹ First, we justify a representation for short-term, intra-industry common ownership based on its prominence in the theoretical and empirical literatures, despite it not necessarily fully capturing a common owner's equity portfolio position. For example, in the early theoretical literature, both Rubinstein and Yaari (1983) and Rotemberg (1984) use such an objective function, as does López and Vives (2019). The recent empirical literature testing the implications of common ownership also seems to focus on common ownership as characterized by short-term, intra-industry common ownership (see, for example, the empirical literature in Schmalz, 2018, 2021).

Second, for long-term, broad common ownership, the objective function reflects the most recent theoretical and empirical literature (see, for example Azar and Vives, 2021a) and, we believe, accurately represents the equity portfolio position of actual (potential) common owners, such as institutional investors. There are a wide variety of institutional investors, each with a variety of financial products that may impact the obligations of the institutional investor. However, institutional investors tend to charge percentage fees of assets under management and have diversified investment portfolios (see, for example, Lewellen and Lewellen, 2022), which may create common ownership incentives for institutional investors since, mathemati-

²⁸Profit weights account for both shareholders' cash flow rights and power over firm decisions.

²⁹We do not comment further on the application of constraints other than to say that, to the best of our knowledge, they are not mentioned in the common ownership literature. Since common ownership builds on profit maximization, we adopt the same constraints as profit maximization.

cally, maximizing total fees is equivalent to maximizing portfolio-level returns.³⁰ Furthermore, some types of institutional investors with significantly large investment portfolios, such as defined contribution pension funds, may have legal duties to their ultimate owners and beneficiaries that only concern financial returns to the pension fund's investment portfolio (see, for example, Schanzenbach and Sitkoff, 2020) rather than any other interest of the ultimate owners or beneficiaries.³¹

Finally, what could be considered as the firm-focused, rather than investor-focused, analogues of common ownership are the cross ownership and horizontal M&A literatures (e.g., Reynolds and Snapp, 1986; Salant, Switzer, and Reynolds, 1983), and the supply chain partial equity ownership and vertical M&A literatures (e.g., Church, 2008; Riordan, 1991). The former set of literatures could be seen as akin to intra-industry common ownership, whilst the latter are akin to inter-industry common ownership of vertically related markets. Thus, one aspect of common ownership that differentiates it from its corporative objectives analogues is the concern for unrelated inter-industry firms and, as discussed further in Appendix C.1. the potential concern for financial claims other than profit.

As a second extension of profit maximization, we consider two types of social responsibility; corporate social responsibility ('CSR') and socially responsible investment ('SRI').³² Each includes giving weight to social issues, or 'society', however, only socially responsible investors also give weight to profits. Thus, the objective functions for each can be written as:

$$\varphi_{CSR} = \sum_t \delta_t \pi_{2,t}$$

$$\varphi_{SRI} = \varphi_{LTP} + \varphi_{CSR}$$

where 'society' is assumed to be the stakeholder group for which $j = 2$ and $\pi_{2,t}$ is the payoff to society at time t . We also propose the following three sets of constraints; participation constraints, legal constraints and social obligation constraints. The notation for participation and

³⁰We acknowledge that this line of reasoning does not consider the costs to institutional investors of maximizing portfolio-level returns, which may be non-negligible (see, for example, Bebchuk and Hirst, 2019), and is therefore more akin to revenue maximization than, say, profit maximization at the institutional investor level (but not the firm-level since such considerations would be incorporated into the Pareto weights constituting the firm-level common ownership incentive parameters). Whilst there is literature on precisely measuring the financial benefits to institutional investors of engaging firms in their investment portfolios (Lewellen and Lewellen, 2022), we are not aware of literature precisely measuring the financial costs (nor are we aware of literature considering the extent to which some costs are borne by directors and managers interested in shareholder preferences to, for example, maintain their position or reputation).

³¹Such as the interests of ultimate owners and beneficiaries as consumers or workers of firms in the investment portfolio, or as those who are impacted by or have preferences over externalities and spillovers from firm behavior (contra Gordon, 1990).

³²The relationship between stakeholder theory, to be outlined further below, and CSR implied by our maximization problems may be surprising to some readers. See Dmytryiev, Freeman, and Hörisch (2021) for a discussion.

legal constraints is as above, whilst the set of actions that satisfy social obligations is denoted A_s . The maximization problems for each type of social responsibility are therefore given by:

$$\begin{aligned}
& \max_a \quad \varphi_{CSR} \\
& \text{s.t.} \quad \tilde{\pi}_1 \geq w_1, \\
& \quad \tilde{\pi}_j \geq w_j \mathbb{1}\{a \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a \in A_{j,cp}\}) \quad \text{for all } j \neq 1, \\
& \quad a \in A_t(F) \quad \text{for all } i. \\
& \quad a \in A_l \quad \text{for all } i, \\
& \quad a \in A_s \quad \text{for all } i.
\end{aligned}$$

$$\begin{aligned}
& \max_a \quad \varphi_{SRI} \\
& \text{s.t.} \quad \tilde{\pi}_1 \geq w_1, \\
& \quad \tilde{\pi}_j \geq w_j \mathbb{1}\{a \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a \in A_{j,cp}\}) \quad \text{for all } j \neq 1, \\
& \quad a \in A_t(F) \quad \text{for all } i. \\
& \quad a \in A_l \quad \text{for all } i, \\
& \quad a \in A_s \quad \text{for all } i.
\end{aligned}$$

We believe these to be accurate representations for the following reasons. First, the set of constraints is appropriate since social responsibility, regardless of its type, is generally considered to involve actions that go "*beyond* the narrow economic, technical, and legal requirements of the firm" (emphasis added) (Davis, 1973). Thus, economic constraints, in the form of participation constraints, production technology constraints (i.e., technical constraints), and legal constraints apply as a minimum, whilst the social obligation constraints impose obligations "*beyond* the requirements of the law" (Davis, 1973).³³

Second, the objective functions span the relevant possibilities with regards to social responsibility. Some regard corporate social responsibility as focusing exclusively on satisfying social obligations, solving social problems and producing social good rather than being concerned with, for example, economic and financial goals (see, for example, Dmytriyev, Freeman, and Hörisch, 2021). For others, it may be that CSR was not intended to supplant, but to supplement, a business' existing profit maximization objective (see, for example, Davis, 1973). Given this disagreement, we provide both forms. We do, however, label the form that includes consideration of profits and social good as SRI since it is quite clear in the SRI literature that social good is considered in addition to financial returns (see, for example, Renneboog, Ter Horst,

³³It may be that these constraints include unconditional participation constraints for some stakeholders, particularly 'society'. However, we have not encountered a clear indication of such constraints in the literature. See stakeholder theory below for evidence of the kinds of indication that may suggest the presence of unconditional participation constraints.

and Zhang, 2008).

Finally, we propose two maximization problems for stakeholder theory (Freeman, 1984) based on two different objective functions; the narrow stakeholder objective function and the wide stakeholder objective function. The narrow and wide stakeholder objective functions differ in the set of stakeholder group payoffs that are given a non-zero discount factor in the objective function. For the narrow objective function, N , the set of stakeholder groups whose payoffs are given a non-zero discount factor, denoted S_N , includes consumers, employees, financial capital providers (e.g., shareholders, bondholders), suppliers and local communities. For the wide stakeholder objective function, the set of stakeholder groups whose payoffs are given a non-zero discount factor, denoted S_W , includes, in addition to those in the set for the narrow objective function, surrounding society, special interest groups, media, government and a firm's competitors. The objective function for each stakeholder objective function, where $k \in \{N, W\}$, can therefore be written as:

$$\varphi_{S_k} = \sum_{j \in S_k} \delta_j \pi_j \quad (4.1)$$

We now suggest three sets of constraints for maximizing Equation 4.1; participation constraints, legal constraints, and purpose constraints. Participation constraints and legal constraints are as presented earlier. Purpose constraints place constraints on the actions of the firm in accord with the company's purpose, mission and values, and will be denoted A_p . Given the above objectives and constraints, we suggest the maximization problem for the firm under stakeholder theory may be conceived as:

$$\begin{aligned} \max_a \quad & \varphi_{S_k} \\ \text{s.t.} \quad & \tilde{\pi}_j \geq w_j \quad \text{for all } j \in S_k, \\ & \tilde{\pi}_j \geq w_j \mathbb{1}\{a \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a \in A_{j,cp}\}) \quad \text{for all } j \notin S_k, \\ & a \in A_t(F) \quad \text{for all } i. \\ & a \in A_l \quad \text{for all } i, \\ & a \in A_p \quad \text{for all } i. \end{aligned}$$

We believe the above objectives and constraints are an appropriate representation of the maximization problem suggested by stakeholder theory for the following reasons. First, for the objective functions, stakeholder theory focuses on creating value for all stakeholders, where 'all stakeholders' can either be defined as "narrow" or "wide" (Dmytriyev, Freeman, and Hörisch, 2021). The "wide" set of stakeholders consists of "those who can affect or be affected by the realization of an organization's purpose", whilst the "narrow" consists of "those without whose

support the organization would not exist." The proponents of stakeholder theory do not concretely define the set of stakeholders in the "narrow" and "wide" groups, and have previously suggested that they continue to hold the constituents of "all stakeholders" open (Freeman, Phillips, and Sisodia, 2020). Thus, for the sake of concreteness, we take the arrangement in Figure 3 of Dmytriyev, Freeman, and Hörisch (2021) as indicative of the constituents of the "narrow" and "wide" groups; the stakeholders in the inner circle constitute the "narrow" group, which is also a group often given as an example of stakeholders (see, for example, Dmytriyev, Freeman, and Hörisch, 2021), and those in the inner and outer circle as the "wide" group. Finally, we note that the narrow stakeholder objective function is consistent with the "Total Value Created" function proposed in Freeman, Phillips, and Sisodia (2020).

Second, the constraints. We consider the legal and purpose constraints first, then the participation constraints. For the legal and purpose constraints, it is important to note that stakeholder theory often emphasizes going beyond the suggestion of Friedman (1970) that firms be run "to increase its profits so long as it[, the firm,] stays within the rules of the game". Specifically, stakeholder theory commits to a broader corporate responsibility of firms to their stakeholders, and the firm's purpose, mission and values, which, therefore, should be incorporated into the maximization problem. Whilst it is possible that such commitments can lead to the relaxation of constraints, such as investing in novel solutions (Dmytriyev, Freeman, and Hörisch, 2021), we model these as placing constraints on the firm's actions since in the first instance such constraints must apply to the decision to attempt to relax constraints. Finally, we include participation constraints to incorporate the notion that "in stakeholder theory, one of the core tasks for managers is generating mutual benefits for all stakeholders" (Dmytriyev, Freeman, and Hörisch, 2021). We believe this notion is captured by the unconditional participation constraints since the unconditional participation constraints indicate the creation of a mutual benefit. We do, however, only apply unconditional constraints to only those stakeholders considered in the objective function.

Our proposed objective functions and constraints, however, may be not entirely consistent with every proposed feature of stakeholder theory. Some important differences, and our opinions on them, include the following. First, by proposing an objective function and maximization problem, we implicitly allow for trade-offs between stakeholder group payoffs. In contrast, under stakeholder theory, it is often emphasized that managers "should... attempt to avoid trade-offs among stakeholders" or focus on "generating mutual benefits... rather than focusing on trade-offs" (Dmytriyev, Freeman, and Hörisch, 2021). Unfortunately, the term "trade-off" remains undefined, and, based on our reading of the literature, may not be meant in the sense it is usually defined within economics and finance. We therefore offer both our translation of and response to our take on its intended meaning, and a response to its meaning in economics and finance.

First, to translate to economics and finance, it may be that what is meant by "avoid a trade-off" is "avoid stakeholder exit", which, as we will suggest, is simply a different framing of "creating mutual benefits" by satisfying unconditional participation constraints. The argument for this translation is four-fold. First, it is consistent with the definition of the narrow stakeholder group as being those without whom the firm would not survive or exist since, if stakeholders entirely exit, the firm by definition would not exist. Furthermore, under the heading of "[e]verything that we do serves stakeholders. We never trade-off the interests of one versus the other continuously over time", Freeman, Harrison, and Wicks (2007) elaborate on the need to focus on "the need in the external environment" in order to "*survive and prosper*" (emphasis added). Second, when discussing trade-offs, it is common for the need to ensure stakeholder participation to be mentioned without discussing how to resolve trade-offs in the sense meant in economics and finance. For example, in Freeman, Harrison, and Wicks (2007) in the same section just mentioned, Freeman, Harrison, and Wicks (2007) only appear to deal with trade-offs to the extent that the firm's "basic business proposition makes its stakeholders better off." As another example, Freeman, Wicks, and Parmar (2004) state "[t]here are, of course, conflicts among stakeholder interests but these conflicts must be resolved so that *stakeholders do not exit the deal - or worse - use the political process to appropriate value for themselves or regulate the value created for others*" (emphasis added). Third, across much of the stakeholder theory literature, there is an emphasis on freedom and voluntarism (see, for example, Freeman, Harrison, and Wicks, 2007; Freeman, Wicks, and Parmar, 2004), which is in some sense captured by participation constraints. Finally, the importance of relationships is emphasized heavily in stakeholder theory (Dmytriyev, Freeman, and Hörisch, 2021) and it is obviously important that participation constraints must be satisfied in order to sustain relationships. Thus, it would seem that "avoiding a trade-off" may simply mean satisfying a stakeholder's participation constraint, where "avoid stakeholder exit" and "create mutual benefit" are different framings of this underlying message.

If, however, "trade-off" is meant as in economics and finance, we are skeptical of the possibility of avoiding trade-offs and the desirability of not focusing on trade-offs for the following reasons. First, ignoring the selection of commitments (i.e. constraints), there exist no trade-offs if and only if there are unique actions (a) that satisfy the commitments (constraints). Otherwise, there exists multiple a , which one must choose from, or, if there is no a that satisfies the constraints, one presumably must decide to remove a constraint, both of which likely involve a trade-off in realistic circumstances.³⁴ Furthermore, since trade-offs are difficult to avoid and generating mutual benefits is arguably satisfied by satisfying the participation constraint, it would seem odd if managers did not focus on trade-offs, at least to a degree that is reasonable

³⁴Even if trade-offs can be "resolved through innovative thinking" (Dmytriyev, Freeman, and Hörisch, 2021), the decision to pursue innovative thinking to supposedly resolve a trade-off requires the use of resources (time, cognition or otherwise) that could've been used otherwise.

in context,³⁵ given that, after the satisfaction of constraints, this is perhaps the only decision that remains and is likely to be an important one to the success of the firm.³⁶

Another important difference is that in the proposed objective functions, stakeholders potentially receive different weightings depending on the discount factors.³⁷ It is, however, unclear how these discount factors should be bounded. For example, Dmytriiev, Freeman, and Hörisch (2021) suggest that "shareholders should not be prioritized over the interests of other stakeholders" whilst, a matter of sentences later, also acknowledge the "facets of stakeholder theory... highlighting the need to select or even prioritize specific stakeholders." Elsewhere, it is also suggested that "stakeholders are equally important" (Freeman and Dmytriiev, 2017). Thus, it seems that any discount factor greater than or equal to zero is allowed. Since discount factors equal to zero may render the objective functions indistinguishable from others we have already proposed, we assume that the discount factors are strictly greater than zero. That is, $\delta_j > 0$.

³⁵Any cost (or benefit) of focusing on trade-offs can be incorporated into the maximization procedure and, therefore, done optimally.

³⁶Dmytriiev, Freeman, and Hörisch (2021) may have implicitly acknowledged this by suggesting that "stakeholder relationships should be based on the principles of fairness and reciprocity." Nonetheless, appropriately managing trade-offs among stakeholders may be important to the success of the business (Bosse, Phillips, and Harrison, 2009).

³⁷An alternative, but usually mathematically equivalent, way to incorporate stakeholder payoffs into the objective function is to use weights. In many cases, the literature uses 'weights' instead of 'discount factors'.

4.3 Does the recent theoretical literature highlight the differences in firm behavior implied by different maximization problems?

In this section, we report the results of examining recent theory papers to see if they explore whether different firm behavior is implied by the maximization problems in Section 4.2. We find that papers only explore differences to the extent that their objective of interest is different to short-term profit maximization. We also (very) briefly discuss how the results for each paper could be replicated by alternative objective functions.³⁸ Before proceeding, however, we note that, to the best of our knowledge, long-term profit maximization has not been the subject of recent theorizing despite its importance in the literature on corporate objectives. We therefore focus on common ownership, social responsibility and stakeholder theory.

4.3.1 Common ownership

In the recent resurgence in the common ownership literature, some of the most cited papers containing theoretical models are López and Vives (2019), Azar and Vives (2021a), Backus, Conlon, and Sinkinson (2021), Antón, Ederer, Giné, and Schmalz (2023) and Antón, Ederer, Giné, and Schmalz (2024).³⁹ In Tables 4.1 and 4.2 below, we list the objective functions used for their theoretical models. As can be seen, all of these models build on profit maximization and, furthermore, in their papers, the authors compare results under profit maximization to results given the objective functions in Tables 4.1 and 4.2. After searching these papers, we found that none discuss how alternative objective functions may generate firm behavior similar to that generated by common ownership.

For concreteness, consider the following alternative explanations for some of the results in each paper. Azar and Vives (2021a), for example, find that common ownership can lead to reductions in output in their one-sector model, whilst common ownership can lead to an increase or decrease in output in their multi-sector model relative to profit maximization. If this pattern of firm behavior were observed, it could arguably also be explained by stakeholder theory and long-term profit maximization. This is because both can generate firm behavior that looks as if weight is given to firms in other sectors, whilst, in the presence of negative externalities, generating reductions in output in the one-sector case. In López and Vives (2019) and Antón, Ederer, Giné, and Schmalz (2024), the existence of large, positive technological spillovers from innovation and common ownership may lead to higher innovation than is the case with profit

³⁸Whilst it may be the case in some of the models presented in this section that alternative objective functions may have no "bite" in the sense that they would not generate different behavior from profit maximization, this defense may be considered to highlight a limitation of the models used. This is because the inclusion of realistic features, even if accounted for in a reduced-form manner and with examples including spillovers, externalities and repeated interaction, may lead to alternative objective functions generating similar firm behavior to that found for the objective function of interest.

³⁹For recent reviews with further theoretical and empirical literature, see Gerardi, Lowry, and Schenone (2024) and Schmalz (2018, 2021).

Paper	Objective function	Notation
López and Vives (2019)	$\pi_i + \lambda \sum_{i \neq k} \pi_k$	<p>i is the firm of interest.</p> <p>π's represent the profits of firms.</p> <p>λ is the weight placed on the profits of firm k relative to the profits of firm i. λ's are identical for all firm k's by assumption in the model.</p>
Azar and Vives (2021a)	$\frac{\pi_{nj}}{P} + \lambda_{intra} \sum_{k \neq j} \frac{\pi_{nk}}{P} + \lambda_{inter} \sum_{m \neq n} \sum_k \frac{\pi_{mk}}{P}$	<p>n is the industry of interest</p> <p>j is the firm of interest</p> <p>π's represent the profits of firms</p> <p>P is the price index</p> <p>λ_{intra} is the weight placed on the profits of firm nk, which is in the same industry as firm i, relative to the profits of firm j.</p> <p>λ_{intra}'s are identical for all firm nk's by assumption in the model.</p> <p>λ_{inter} is similar to λ_{intra}, however, firm mk is not in the same industry as firm nj.</p> <p>λ_{inter}'s are identical for all firms mk's by assumption in the model.</p>
Backus, Conlon, and Sinkinson (2021)	$\pi_f + \sum_{g \neq f} \kappa_{fg}(\gamma_f, \beta) \cdot \pi_g$	<p>f is the firm of interest</p> <p>π's represent the profits of firms</p> <p>$\kappa_{fg}(\gamma_f, \beta)$ is the weight placed on the profits of firm g relative to firm f. γ_f is a vector of Pareto weights at firm f for each investor s. β is the vector of cash flow rights attributable to investor s across all firms.</p>

Table 4.1: Objective functions from the theory of common ownership (1)

Paper	Objective function	Notation
Antón, Ederer, Giné, and Schmalz (2023)	For symmetric ownership, see López and Vives (2019)	
	For asymmetric ownership, see Backus, Conlon, and Sinkinson (2021)	
Antón, Ederer, Giné, and Schmalz (2024)	See Backus, Conlon, and Sinkinson (2021)	

Table 4.2: Objective functions from the theory of common ownership (2)

maximization. Since social responsibility, stakeholder theory and long-term profit maximization also encourage the consideration of spillovers, such behavior could also be rationalized by a firm acting according to these objectives.⁴⁰ Antón, Ederer, Giné, and Schmalz (2023) predict that common owners may allow managers to enjoy the "quiet life" by placing less emphasis on cost-reducing productivity improvements (as an alternative to explicitly increasing prices) and, thus, reduce the performance sensitivity of managers' remuneration. Since such costs are often the income of other stakeholders, it is plausible that reduced cost sensitivity might also be generated by stakeholder theory and long-term profit maximization. Finally, Backus, Conlon, and Sinkinson (2021) predict the possibility of tunneling in widely-held firms. Given social responsibility focuses on doing social good and stakeholder theory does not appear to place upper bounds on the discount factors in its objective function, tunneling can also be generated by these objectives.⁴¹

4.3.2 Social responsibility

Recent theoretical papers focusing on social responsibility include Hart and Zingales (2017), Morgan and Tumlinson (2019), Broccardo, Hart, and Zingales (2022), Edmans, Levit, and Schneemeier (2023), and Oehmke and Opp (2024). In Tables 4.3 and 4.4 below, we list the objective functions used for their theoretical models. In contrast to Section 4.3.1, these objective functions are for shareholders (or investors) rather than the firm.⁴² Similar to those papers presented in Section 4.3.1, all of these models build on profit maximization and the authors compare results under profit maximization to results under the objective functions in Tables 4.3 and 4.4. We also found no discussion of how results for alternative objective functions may differ to those results given for social responsibility. Given that all of these models include an externality or spillover, the results for firm behavior could also be explained by stakeholder theory, long-term profit maximization and common ownership. This is because each either results in consideration of externalities and spillovers, or can induce firm behavior that mimics the firm behavior implied in these models.

⁴⁰In López and Vives (2019) and Antón, Ederer, Giné, and Schmalz (2024), it is also the case that small, positive technological spillovers and common ownership may lead to lower innovation than is the case with profit maximization. This is because output and innovation are modeled as complements, and, therefore, if the incentive to reduce output effectively outweighs the incentive to increase investment, then output and innovation may also fall in equilibrium. Thus, similar to Azar and Vives (2021a), this result could also be replicated by the presence of a sufficiently strong negative externality that is taken into account by socially responsible investors, long-term profit maximizers, or some form of stakeholder theory.

⁴¹Similar to Backus, Conlon, and Sinkinson (2021), we are simply pointing out that such behavior is possible whilst we are also skeptical of its possibility.

⁴²In the models in these papers, the interaction between shareholders, or investors, and management, or an entrepreneur, is modeled. Thus, no firm objective is explicitly stated. If the mechanisms modeled in these papers result in Pareto efficient choices, it may be the case that the firm objective could be represented as a weighted function of shareholder, or investor, and manager, or entrepreneur, objectives in a similar manner to the common ownership literature. Since our focus, however, is on social responsibility, we have provided the objectives for the agents who were presented as socially responsible.

Paper	Objective function	Notation
		i indexes shareholders
		λ_i is the weight shareholder i places on social surplus
Hart and Zingales (2017)	$(1 - \lambda_i)\alpha_i\pi + \lambda_i\alpha_i\Pi$	α_i is shareholder i 's ownership of the firm
		π is the profit of the firm
		Π is social surplus
		$u(\cdot, \cdot)$ is the utility function of a representative shareholder
		c is consumption of private goods
		g is consumption of public goods
Morgan and Tumlinson (2019)	$u(c, g) = u\left(\frac{\pi - \alpha}{n}, \alpha - \psi\right)$	π is the profit of the firm
		α is the contribution of the firm to public goods
		n is the number of shareholders
		ψ is the damage to public goods from production
Broccardo, Hart, and Zingales (2022)	$\alpha_i\pi + \lambda_i\Pi$	See Hart and Zingales (2017)

Table 4.3: Objective functions from the theory of social responsibility (1).

Paper	Objective function	Notation
		<p>$f(\cdot, \cdot, \cdot)$ is a function representing a negative externality to society</p> <p>λ is an externality scaling parameter</p> <p>$\theta \sim N(\mu, \sigma)$ is the random value of the firm's assets in place</p> <p>r is the gross return from new investments</p> <p>I is new investments</p> <p>ξ is a parameter determining the effectiveness of an action to reduce the externality</p> <p>a is an action to reduce the externality</p> <p>φ a weighting between the blockholder's trading profits and the externality</p> <p>x is the number of shares held by the blockholder</p> <p>v fundamental value of the firm per share</p> <p>p per share price of the firm's stock</p>
Edmans, Levit, and Schneemeier (2023)	<p>Responsible</p> $\mathbb{E}[-f(\theta, rI, a)] = \mathbb{E}[-\lambda(\theta + rI)(1 - \xi a)]$ <p>Profit-motivated</p> $\mathbb{E}[\varphi x(v - p) - (1 - \varphi)f(\theta, rI, a)]$	
		<p>p is the probability of the firm generating positive cash flow</p> <p>X^{SR} is the payment promised to the SR fund</p>
Oehmke and Opp (2024)	<p>Narrow</p> $pX^{SR} - I^{SR} - \gamma^{SR}\phi_\tau K \mathbb{1}_{I^{SR} > 0}$ <p>Impact</p> $pX^{SR} - I^{SR} - \gamma^{SR}\phi_\tau K$	<p>I^{SR} is the amount invested by the SR fund</p> <p>γ^{SR} is the SR fund's social responsibility parameter</p> <p>ϕ_τ is the per unit social cost for production technology $\tau \in \{Clean, Dirty\}$.</p> <p>$K$ is firm scale</p>

Table 4.4: Objective functions from the theory of social responsibility (2).

4.3.3 Stakeholder theory

Recent theoretical papers on stakeholder theory include Magill, Quinzii, and Rochet (2015) and Fleurbaey and Ponthière (2023). In Table 4.5 below, we list the objective functions used for their theoretical models. Similar to the recent theoretical models in the common ownership and social responsibility literatures, all of these models build on profit maximization and the authors compare results under profit maximization to results given the objective functions in Table 4.5. We also found no discussion of how results for alternative objective functions may differ to those results given for stakeholder theory. In Magill, Quinzii, and Rochet (2015), for example,⁴³ the internalization of externalities by profit maximizing firms could be achieved through repeated interactions with other stakeholders, which implies long-term profit maximization could replicate the results. Depending on the nature of the externality, the same could be said of social responsibility.

⁴³We do not discuss Fleurbaey and Ponthière (2023) since their results do not focus on firm behavior other than the entry decision. For a result related to their ‘Profit Selection Theorem’, which is a result related to free-entry equilibria, see Appendix C.2.

Paper	Objective function	Notation
		<p>r is the discount rate on future payoffs is</p> <p>π is the probability of outcome s, which can be good, g, or bad, b</p> <p>$CS_s(\cdot)$ is consumer surplus</p> <p>p_s is price paid by consumers</p> <p>$W_s(\cdot)$ is worker surplus</p> <p>w_s is the wage for workers</p> <p>$R_s(\cdot)$ is the profits for shareholders</p> <p>l_s is the firm's demand for labour, which also corresponds to its output choice</p> <p>$\gamma(\pi)$ is an expense that affects π_s</p>
Magill, Quinzii, and Rochet (2015)	$\frac{1}{1+r} \sum_{s=g,b} \pi_s (CS(p_s) + WS(w_s) + R_s(l_s)) - \gamma(\pi)$	
		<p>i indexes agents</p> <p>$WTP_i(q_i)$ is the willingness to pay for q_i from the firm</p> <p>$WTA_i(x_i)$ is the willingness to accept to provide x_i to the firm</p> <p>$V(E)$ is the damage from negative externalities</p>
Fleurbay and Ponthière (2023)	$\sum_i WTP_i(q_i) - \sum_i WTA_i(x_i) - V(E)$	

Table 4.5: Objective functions from stakeholder theory

4.4 Conclusion, discussion and suggestions for future research

In this paper, we have outlined maximization problems for firms based on prominent theories of the firm or prominent theories of firm, investor or manager objectives. In doing so, we hope to have clarified the differences between various theories and, in contrast to the current literature which focuses almost entirely on objective functions, highlighted the importance of the constraints proposed for each theory. We also survey the recent theoretical literature to determine whether papers explore the different firm behaviors implied by the different maximization problems and find that the theoretical literature does not explore such differences. We therefore close this section by first addressing two potential concerns with our result, highlighting important limitations, then suggesting areas for future research.

The first concern relates to the *market selection hypothesis* (for a useful summary of the *market selection hypothesis*, see Blume and Easley, 2002), which is a theoretical argument against the existence of non-profit maximizing firms in the long-run due to dynamic market forces; after all, if non-profit maximizing firms are unlikely to exist due to the nature of the economic environment, why study them? Here we briefly address two important components of this argument as identified by Blume and Easley (2002).⁴⁴ The first component is that capital markets will select only profit maximizing firms (through, for example, the market for corporate control). Leaving aside possible features of market regulation and corporate governance that may protect non-profit maximizing firms from takeover or promote their financing, and assuming capital providers are purely (single-firm-)profit-motivated, the conventional argument for this result is that capital providers will either fund only profit maximizing firms because profit maximizing firms make more profit, or takeover non-profit maximizers because by doing so such firms will make more profit. However, even if firms are identical other than their objective functions, it is not necessarily the case that profit maximizing firms make more profit than non-profit maximizing firms when competing as per conventional models of markets (Fershtman and Judd, 1987; Lambertini and Tampieri, 2015; Rotemberg, 1984).⁴⁵ Thus, all else equal, even (single-firm-)profit maximizing capitalists may prefer non-profit maximizing firms.

The second component is that competitive product markets will also either select for profit maximizers or force non-profit maximizers to become profit maximizers. In dynamic models, these arguments tend to rely on product market competition ‘selecting’ the firms that are more profitable than other firms (see, for example, Blume and Easley, 2002). However, as just discussed, profit maximizers are not necessarily more profitable than non-profit maximizers.

⁴⁴We do not address whether conventional market equilibria adequately describe the postulated long-run dynamic processes.

⁴⁵There may be other features of interactions between firms and agents that influence the (implied) objective function of a firm. For example, the incompleteness of contracts (see, for example, Grossman and Hart, 1986) may affect the distribution of surplus among agents through the choices made by firms and, therefore, the firm objective function implied by the choices of the firm.

In static models, not only is a similar argument made to that in dynamic models (which can therefore be questioned on a similar basis), but it has also been argued that some types of non-profit maximizers, specifically "responsible" firms, will be forced to "adopt the profit objective" (Fleurbaey and Ponthière, 2023). However, whilst it may be the case that responsible firms may be evicted from the market and in competitive product markets, we show in Appendix C.2 that non-profit maximizers are not necessarily forced out of the market.⁴⁶ Therefore, some non-profit maximizers may not be forced to "adopt the profit objective", indicating that competitive product markets may not always select for profit maximizers.

The second concern is that the classification problem is resolved in the empirical literature rather than the theoretical literature. To address this concern, and with a view to integrating the results into the body of this paper in the future, we are also in the process of surveying the empirical literature. The results to date can be found in Appendix C.3. We have two main preliminary findings. First, the empirical literature, like the theoretical literature, does not address the potential for their results to be explained by objective functions other than their objective function of interest or profit maximization. Second, assuming the papers surveyed have adequately addressed important identification issues, for the set of empirical results surveyed, there does not appear to be an objective function that explains all of the results. The results from the empirical literature do, however, appear to rule out short-term profit maximization as the firm's objective function.⁴⁷

Our results are subject to some important limitations. First, we have necessarily focused on only a subset of the theoretical literature. To partially address this problem, in Appendix C.1 we provide further maximization problems, however, this extended taxonomy still remains only a subset. Similarly, we have focused on recent theoretical literature in assessing whether firm behavior is compared across different maximization problems. Whilst it is possible that there is literature we have not included that is not subject to this critique, it may be considered unlikely given the same result appears to arise in the empirical literature. Third, our alternative explanations for the theoretical results in Section 4.3 are very brief and therefore may lack the rigor of results derived from adequately formulated models. However, given the main point of Section 4.3 is that the papers therein do not consider alternative explanations for their results, the alternative explanations we present should be seen as problematizing the results presented rather than offering a rigorous alternative explanation. Fourth, we have tended to treat the firm as acting according to one type of maximization problem or objective function.

⁴⁶This is essentially another instance of the classification problem and demonstrates an environment in which firm behavior may not be characterized by a unique maximization problem or objective function.

⁴⁷This conclusion was reached by treating each study as a round in a process of elimination of maximization problems for firms or investors. Specifically, we generally, but not always, observed that short-term profit maximization was the null hypothesis that was rejected. However, we generally did not observe the rejection of other maximization problems. We also generally observed that the rejection of short-term profit maximization could be explained by maximization problems other than the maximization problem presented as an alternative to short-term profit maximization.

However, given a firm's behavior results from many interactions of many agents with possibly heterogeneous maximization problems, it may be the case that a firm's behavior is most accurately characterized by some mixture of maximization problems, which is an issue we address further below.⁴⁸ Finally, our survey has largely neglected the role of risk in agents' objective functions. Whilst risk preferences featured in the early theoretical work in economics on firms' objective functions (see, for example, Grossman and Stiglitz, 1977; Grossman and Hart, 1979; Leland, 1974) and risk may be used to justify the adoption of some objective functions, risk preferences do not appear to be a prominent feature of more recent theories of the firm or firm, investor and manager objective functions.

Given these results and limitations, we suggest the following three areas for future research. First, if the classification problem is to be solved, empirically feasible theoretical results will need to be developed that isolate unique measures of firm behavior implied by various maximization problems. Furthermore, these results will need to be integrated into coherent arguments. Relative to some of the existing theoretical literature, this may require the development of models of the firm and its external environment that are minimally complex but sufficiently realistic for this task by including, for example, strategic interaction, externalities, spillovers, repeated interaction and risk preferences in a manner in which all relevant stakeholders' payoffs are affected. An initial, but somewhat 'reduced-form', attempt at doing so can be found in our paper Annabel, Asher, and Ghosh (2022) where we compare the sign of firm behavior across comparisons to short-term profit maximization.⁴⁹ Relative to some of the existing empirical literature, the arguments constructed in empirical papers should be valid by, for example, applying a process of elimination (or falsification, rather than verification) to establish truth claims about whether firms, investors, or managers follow particular maximization problems.⁵⁰

⁴⁸We are by no means the first to make this point. An early example is Jensen and Meckling (1976), who suggest "[v]iewing the firm as the nexus of a set of contracting relationships among individuals also serves to make it clear that the personalization of the firm implied by asking questions such as 'what should be the objective function of the firm', or 'does the firm have a social responsibility' is seriously misleading. *The firm is not an individual*. It is a legal fiction which serves as a focus for a complex process in which the conflicting objectives of individuals (some of whom may 'represent' other organizations) are brought into equilibrium within a framework of contractual relations." (emphasis not added)

⁴⁹This approach was used because we believe the unit of analysis (i.e., differences in preferences) is, relative to the conventional incentive parameter approach, more closely aligned with the 'power-based approaches' in Appendix C.3.1.1. Given the empirical methodologies outlined Appendix C.3, we do not believe there is a need to develop new theoretical approaches beyond what is mentioned in the remaining paragraphs. Rather, unique sets of predictions or hypotheses using current theoretical approaches may be sufficient.

⁵⁰One might argue that certain problems, such as the one that is the focus of this paper, are 'empirical problems'. We, however, doubt that this is the case for the following reasons. First, many empirical results rely on i) identification assumptions about 'unobservables', which are unverifiable by definition of the term 'unobservable' and therefore may require a theoretical justification, and ii) interpretation and characterization, rather than mere description, of results, which therefore requires a theoretical model with which to interpret and characterize the results. Second, much of the quantitative empirical work in this field involves constructing arguments, which also have a theory of valid construction.

Second, the application of the weighted objective (or utility) function approach to combining agents' preferences into a firm objective function in theoretical and empirical models may need to be reconsidered due to the presence of heterogeneous constraints in agents' maximization problems. Specifically, it seems that the use of Pareto weights, which, for example, is prevalent in the common ownership literature, to aggregate agents' objective functions into a firm objective function may not always be feasible. This is because there may not exist a constrained maximization problem, where constraints are drawn only from the constraints of the maximization problems of the agents involved, with Pareto weights that can rationalize the firm choice and agents' objective functions. To see how, consider the following simple example. Suppose there are two agents in a firm; agent 1 and agent 2. Both agents are profit maximizers, but only agent 1's maximization problem involves satisfying legal constraints (there is not perfect enforceability of the law).⁵¹ Suppose the firm must decide on an action, a , agent 1 and agent 2 have equal control of the firm, the action under consideration is illegal, the unconstrained profit maximizing level of the illegal action, a^* , is greater than zero, i.e. $a^* > 0$, and, for simplicity, both agents' participation constraints are satisfied for any choice of a . Since agent 1 and agent 2 have equal control of the firm, the firm's choice is $a^*/2$. There are two possibilities for the firm maximization problem with Pareto weights; one without legal constraints and one with legal constraints. Without legal constraints, there does not exist Pareto weights that rationalize $a^*/2$ since, without legal constraints, both agents prefer a^* . With legal constraints, the observed action, $a^*/2$, is not in the feasible set of the proposed constrained maximization problem for the firm, which includes $a = 0$ only since the action is illegal. Therefore, there may not exist a constrained maximization problem for the firm based on Pareto weighting agents' objective functions that can rationalize the firm's choice and the objective functions of agents.⁵²

Finally, given this theoretical problem and the preliminary results of our empirical survey, we suggest further development of theoretical tools and methods (such as maximization problems) for succinctly characterizing, explaining and predicting firm behavior as if the firm is unitary. Whilst the mixed results in the empirical literature may be attributable to various factors that do not necessarily falsify the application of some of the maximization problems or objective functions presented in Section 4.2,⁵³ it may also be that none of the maximization problems or objective functions presented in Section 4.2 explain all of the results as indicated by our preliminary findings from the ongoing empirical survey. Combining this problem with

⁵¹Here we are treating the legal constraints as representing agent 1's lexicographic preference for following the law over profits.

⁵²This simple example can be extended to more than two agents if each agent has non-zero control and at least one agent is law-abiding. Furthermore, it does not necessarily require that the set of law-abiding actions is a singleton. For example, the legal requirements may instead specify that $a < \bar{a}$, where $0 < \bar{a} < a^*$ and profit is strictly concave in a . In the two agent case, the firm choice will be $\frac{\bar{a}+a^*}{2}$, which, for similar reasons given in the paragraph of this footnote, cannot be rationalized by a maximization problem using weighted objective functions and only the constraints of the two agents.

⁵³For example, there may be identification issues or publication biases that we have not addresses that could explain the mixed results we observe.

the problem observed in the previous paragraph and assuming that a generalized approach is desired,⁵⁴ it may even be that an alternative decision problem to maximization problems, where firms are still treated as if they are unitary, leads to improved characterizations, explanations and predictions for firm behavior.

⁵⁴By generalized approach, we mean the use of a single model or theory for a firm or investor. There may, however, be alternatives that others find suitable for their theoretical or empirical application. For example, multiple models could be formulated and Bayesian model averaging used. Another alternative may be to reduce the application of some maximization problems or objective functions to particular aspects or domains of firm behavior. Such an approach might then resemble state-dependent utility functions.

Chapter 5

Conclusion and Discussion

In this thesis, I develop improved arguments and methods for interpreting and characterizing the effect of institutional investors on firm behavior, which has important implications for the practice and regulation of active ownership (or, using the recently more popular terminology, stewardship¹) by institutional investors. To develop these improved arguments and methods, I identify and contribute to addressing two important problems in the literature. The first problem, which is identified in Chapter 4, is that many plausible and important alternative characterizations for both theoretical and empirical results remain unexplored because most papers tend to consider only two possible objective functions when characterizing the effect of institutional investors on firm behavior; profit maximization and some other objective function. To contribute to addressing this problem, in Chapter 4 I provide a taxonomy of maximization problems, which could be of use to other researchers in solving the "classification problem". This taxonomy may also be of use to practitioners in developing an understanding of the meaning and likely impact on firm behavior (and, therefore, by extension, the impact on the value of their investment portfolio) of particular claims about and actions derived from their approach to active ownership, and regulators in understanding and developing appropriate regulatory policy for the promises made in relation to and impact of institutional investors' active ownership. In Chapter 2, I also provide a novel set of theoretical results for uniquely characterizing the effect of institutional investors on firm behaviors when firms emit greenhouse gas emissions, which serves as a useful and salient example for academics, practitioners and regulators of how the taxonomy can be used for the purposes above.

The second problem is that, for the "social choice power regressions" often used to analyze the effect of institutional investors on firm behavior (see Appendix C.3.1.1 in Chapter 4), there has not been, to the best of my knowledge, any research on the micro-foundations, proper interpretation and structural estimation of "social choice power regressions." To contribute to

¹See, for example, the United Nations Principles for Responsible Investment (2025)

addressing this problem, in Chapter 3 I develop a "power-based framework" for analyzing the effect of an agent, or group of agents (such as institutional investors), on social choices (such as firm choices). Where the proxy for power is a binary treatment variable, I then demonstrate through an application to Ashraf, Field, and Lee (2014) the usefulness of this framework for interpreting the estimated effects, developing bounds on effects, and developing measures of "power" for use in structural estimation. Whilst not directly applied to institutional investors in Chapter 3, it can be, as will be outlined below. Thus, the "power-based framework" with a binary variable may be a useful, quantitative, empirical tool for practitioners and regulators for inferring the most-preferred firm choices of institutional investors from measures of the influence, or "power", of institutional investors over firms.

These contributions, however, are subject to limitations, many of which I address in the chapters detailing each contribution. Therefore, in this chapter, I discuss the limitations of these contributions only with respect to the two problems they are intended address and suggest areas for future research related to these problems. First, whilst serving as a potentially important result indicating that it is possible to solve the theoretical aspect of the "classification problem", the theoretical results for characterizing the effect of institutional investors on firm behaviors provided for the first problem are based on models that likely require enrichment to provide a better approximation of reality. Whilst I do believe that the results would generalize if aspects of the models were generalized (for further discussion, see Section 2.4), there are likely some firm choices and behaviors that are not modeled which would enrich the results. For example, there is a large literature on the effects of externalities and positive spillovers from technological and product innovation on firms' quantity and price choices (see, for example, the literature review section of López and Vives, 2019). Thus, since firms' quantity and price choices are affected, the results presented in Chapter 2 may also be affected by externalities and positive spillovers from technological and product innovation. Furthermore, given strategic interaction is important to the firm behavior implied by some maximization problems, such as common ownership but also stakeholder-oriented shareholders as discussed in Section 2.3.4.4, the assumed maximization problems and objective functions for competitor firms may have important implications for the results. Thus, given the challenge and the potential importance of these results to academics, practitioners and regulators as outlined above, enriching the models used in Chapter 2 to provide better approximations of reality may be an interesting and useful area for future research.

Second, whilst the contributions in Chapter 3 provide a solid foundation for further work in analyzing the effects of institutional investors on firm behavior, the contributions from Chapter 3 are not directly applied to doing so. However, if one were to do so, two important aspects of Chapter 3 are directly transferable to existing approaches; the use of only two agents, which are the agent of interest and benchmark agent, and the use of binary variables. First, the agent of interest may be taken to be institutional investors, typically as a group follow-

ing the literature, and, based on previous approaches in the literature, the benchmark agent may be managers (and directors) or a short-term profit maximizer. Managers, collectively, as the benchmark agent is the precedent in much of the research in corporate governance, particularly under agency theory, since managers tend to make many important firm decisions.² However, as discussed in footnote 67 of Chapter 2, it also appears that a (short-term) profit maximizing firm is sometimes assumed to be the benchmark agent. Nonetheless, since the benchmark agent can be a hypothetical agent (see footnote 29 in Chapter 3), the "power-based framework" can accommodate either assumption. In each case, however, it remains important for the application of the results in Section 3.3.2 of Chapter 3 that the requisite assumptions be validated, which may depend on the assumed benchmark agent. Second, in the literature investigating the effects of institutional investors on firm behavior, binary variables are often used either as proxies for the power of institutional investors or as instrumental variables for the proxies for the power of institutional investors. To the extent that these binary variables can be viewed as binary *treatment* variables and that any effect such binary variables may also have on institutional investors' most-preferred firm choices can be addressed using similar approaches to Section 3.3.3, the results of Chapter 3 are directly transferable to existing approaches. Nonetheless, as discussed in Section 3.4, extending the application of the framework beyond binary treatment variables may be a useful area for future research, with important implications for practitioners and regulators. In particular, to the extent that the above, relatively inexpensive approach cannot feasibly be implemented (which strictly includes validating the assumptions) and further developments on the approach or similarly inexpensive alternative approaches³ are not made, practitioners and regulators may need to rely on relatively more expensive, qualitative approaches to recover information about and characterize institutional investors' effects on firm behavior.

Finally, whilst I contribute to addressing these two separate problems, at least one important question remains: explicitly, how can these two contributions be used to solve the overall problem of interpreting and characterizing the the effect of institutional investors on firm behavior? Given the above discussion, and the areas for future research notwithstanding, these two results can be used to interpret and characterize the the effect of institutional investors on firm behavior as follows. First, assume the benchmark agent is a short-term profit maximizer. Second, find a binary variable that plausibly affects institutional investor power that can be considered a binary *treatment* variable and satisfies the requisite assumptions of the results in Section 3.3.2. Third, apply social choice power regressions in the samples corresponding to the industry conditions identified in Chapter 2, which are summarized in Figure 2.2. Fourth, given the sign of the effect of the binary variable in the social choice power regressions, use the results in Section 3.3.2 and, if necessary and feasible given the characteristics of the bi-

²Treating managers as a single agent is akin to treating institutional investors as a single agent.

³See Appendix C.3 for alternative approaches and my tentative conclusions about their feasibility.

nary variable, Section 3.3.3 to infer the sign of the difference in most-preferred firm choices between institutional investors and the hypothetical short-term profit maximizer. Finally, use the signs of these differences and the results in Chapter 2, which are summarized in Figure 2.2, to characterize institutional investors by one of the objective functions analyzed therein.

Appendix A

Appendices for Chapter 2

A.1 Model set-up

A.1.1 Profits of Sector Y and wages

The profits of a firm in Sector Y is given by:

$$\pi_Y = p_Y y - w L_y. \quad (\text{A.1})$$

Since y is the numeraire, $p_Y = 1$. Since competition in Sector Y is perfect, $\pi_Y = 0$. Noting the production function for firms in Sector Y is $Y = L_y$ so that the marginal cost of labor per unit of production of Y , $\frac{\partial L_Y}{\partial Y}$, is $\frac{\partial L_Y}{\partial Y} = 1$, it follows that:

$$\pi_Y = p_Y y - w L_y = y - w y = 0, \quad (\text{A.2})$$

which implies the wage rate, w , is $w = 1$.

A.1.2 Long-term profit expressions for Sector Q and Sectors R_n

The long-term profit for firm i in Sector Q is given by:

$$\tilde{\pi}_{Q,i} = p_Q q_i - w L_Q - t e_i - \delta \gamma_f E. \quad (\text{A.3})$$

Now since $w = 1$ and noting that the marginal cost of labor per unit of production, $\frac{\partial L_Q}{\partial Q}$, is $\frac{\partial L_Q}{\partial Q} = c$, the profit function can be written as:

$$\tilde{\pi}_{Q,i} = p_Q q_i - c q_i - t e_i - \delta \gamma_f E. \quad (\text{A.4})$$

A similar line of reasoning can be followed to derive the profit function of firms in Sectors R_n .

A.1.3 Demand functions

representative consumer aims to maximise its utility:

$$U_j(Q_j, R_{n,j}, y_j) = y_j - \delta\gamma_{cw}E + aQ_j - \frac{Q_j^2}{2} + \sum_n aR_{n,j} - \frac{R_{n,j}^2}{2} \quad (\text{A.5})$$

subject to the constraint $wLj \geq y_j + p_Q Q_j + \sum_n p_{R_n} R_{n,j}$. The Langrangian, \mathcal{L} , of the constrained maximisation problem is given by:

$$\mathcal{L} = U_j(Q_j, R_{n,j}, y_j) + \varphi(wLj - y_j - p_Q Q_j - \sum_n p_{R_n} R_{n,j}). \quad (\text{A.6})$$

Taking the first order condition with respect to φ gives the binding budget constraint:

$$\frac{\partial \mathcal{L}}{\partial \varphi} = wLj - y_j - p_Q Q_j - \sum_n p_{R_n} R_{n,j} = 0 \implies wLj = y_j + p_Q Q_j + \sum_n p_{R_n} R_{n,j}. \quad (\text{A.7})$$

The first order condition with respect to y_j gives φ :

$$\frac{\partial \mathcal{L}}{\partial y_j} = 1 - \varphi = 0 \implies \varphi = 1. \quad (\text{A.8})$$

The first order condition with respect to Q_j is given by:

$$\frac{\partial \mathcal{L}}{\partial Q_j} = a - Q_j - \varphi p_Q = 0 \implies Q_j = a - p_Q. \quad (\text{A.9})$$

Noting that $E = E_0 + Q$ and, due to the unit mass assumption, $Q = \int_0^1 Q_j dj$ so that $\frac{\partial E}{\partial Q_j} = \frac{\partial Q}{\partial Q_j} = 1$. This solution is a global maximizer. Since the utility function is strictly quasiconcave and the budget constraint is convex, there is a unique global constrained maximizer. Since the first order conditions result in a unique solution, this solution must be the global maximizer.

Finally, demand for good q in Sector Q is therefore given by:

$$Q = \int_0^1 Q_j dj = \int_0^1 a - p_Q dj = a - p_Q, \quad (\text{A.10})$$

where it is assumed $a > Q$ so that $p_Q > 0$.

A similar line of reasoning can be followed to derive the demand functions in Sectors R_n .

A.1.4 Emissions tax

Assume the government aims to implement a socially optimal emissions tax assuming firms are short-term profit maximizers (i.e., in the benchmark model. See Appendix A.2.1). To find the socially optimal tax, we find the socially optimal market quantity that maximizes welfare

in the absence of taxes, then equate the socially optimal market quantity to the total market quantity with taxes. Since welfare is maximized when prices equal marginal costs, it follows that:

$$p_Q^* = c + \delta\gamma \implies Q^* = a - c - \delta\gamma. \quad (\text{A.11})$$

Thus, to derive the socially optimal tax:

$$Q^* = Q_{BM}^* \implies t^* = \frac{1}{2}(3\delta\gamma - (a - c)), \quad (\text{A.12})$$

where $Q_{BM}^* = 2q_i^*$. Note that t^* can be negative or positive. A negative t^* indicates a subsidy. This arises because there are two distortions in the market; imperfect competition and the negative externality. To ensure $t^* > 0$ assume:

$$a < c + 3\delta\gamma. \quad (\text{A.13})$$

A.2 Models for Section 2.2

A.2.1 The benchmark model

A Nash equilibrium is found by firm i choosing quantities, q_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned}\phi_{STP} &= \pi_{Q,i} \\ &= (p_Q - c)q_i - te_i\end{aligned}\tag{A.14}$$

$$= (a - q_i - q_{-i} - c - t)q_i\tag{A.15}$$

since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, and $q_i = e_i$. The first order condition is given by:

$$\frac{\partial \phi_{STP}}{\partial q_i} = a - 2q_i - q_{-i} - c - t = 0\tag{A.16}$$

and thus, whilst noting $\frac{\partial^2 \phi_{STP}}{\partial q_i^2} = -2 < 0$ so that the solution is a maximum, the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - q_{-i} - c - t}{2}.\tag{A.17}$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - c - t}{3},\tag{A.18}$$

where it is assumed $a > c + t$ so that $q_i^* > 0$.

A.2.2 Long-term profit maximizer

A Nash equilibrium is found by firm i choosing quantities, q_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned}\phi_{LTP} &= \tilde{\pi}_{Q,i} \\ &= \pi_{Q,i} - \delta\gamma_f E \\ &= (a - q_i - q_{-i} - c - t - \delta\gamma_f)q_i - \delta\gamma_f(E_0 + q_{-i}) \\ &= (a - q_i - q_{-i} - \tilde{c})q_i - \delta\gamma_f(E_0 + q_{-i}),\end{aligned}\tag{A.19}$$

where $\tilde{c} = c + t + \delta\gamma_f$, and since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, $E = E_0 + e_i + e_{-i}$, and $q_i = e_i$. The first order condition is given by:

$$\frac{\partial \phi_{LTP}}{\partial q_i} = a - 2q_i - q_{-i} - \tilde{c} = 0\tag{A.20}$$

and thus, whilst noting $\frac{\partial^2 \phi_{LTP}}{\partial q_i^2} = -2 < 0$ so that the solution is a maximum, the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - q_{-i} - \tilde{c}}{2}. \quad (\text{A.21})$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - \tilde{c}}{3} = \frac{a - c - t - \delta\gamma_f}{3}, \quad (\text{A.22})$$

where it is assumed $a > c + t + \delta\gamma_f$ so that $q_i^* > 0$.

A.2.3 Short-term common owner

A Nash equilibrium is found by firm i choosing quantities, q_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned} \tilde{\phi}_{STCO} &= \pi_{Q,i} + \lambda_{INTRA,Q}\pi_{Q,-i} + \sum_n \lambda_{INTER,R_n}(\pi_{R_n,k_n} + \lambda_{INTRA,R_n}\pi_{R_n,-k_n}) \\ &= (a - q_i - q_{-i} - c - t)(q_i + \lambda_{INTRA,Q}q_{-i}) \\ &\quad + \sum_n \lambda_{INTER,R_n}(\pi_{R_n,k_n} + \lambda_{INTRA,R_n}\pi_{R_n,-k_n}) \end{aligned} \quad (\text{A.23})$$

since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, and $q_i = e_i$. The first order condition is given by:

$$\frac{\partial \tilde{\phi}_{STCO}}{\partial q_i} = a - 2q_i - q_{-i} - c - t - \lambda_{INTRA}q_{-i} = 0 \quad (\text{A.24})$$

and thus, whilst noting $\frac{\partial^2 \tilde{\phi}_{STCO}}{\partial q_i^2} = -2 < 0$ so that the solution is a maximum, the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - (1 + \lambda_{INTRA})q_{-i} - c - t}{2}. \quad (\text{A.25})$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - c - t}{3 + \lambda_{INTRA}}, \quad (\text{A.26})$$

where it is assumed $a > c + t$ so that $q_i^* > 0$.

A.2.4 Long-term common owner

A Nash equilibrium is found by firm i choosing quantities, q_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned}\tilde{\phi}_{LTCO} &= \pi_{Q,i} + \lambda_{INTRA,Q}\pi_{Q,-i} + \sum_n \lambda_{INTER,R_n}(\pi_{R_n,k_n} + \lambda_{INTRA,R_n}\pi_{R_n,-k_n}) - \delta\gamma_{CO}E \\ &= (a - q_i - q_{-i} - c - t)(q_i + \lambda_{INTRA,Q}q_{-i}) - \delta\gamma_{CO}q_i \\ &\quad + \sum_n \lambda_{INTER,R_n}(\pi_{R_n,k_n} + \lambda_{INTRA,R_n}\pi_{R_n,-k_n}) \\ &\quad - \delta\gamma_{CO}(E_0 + q_{-i})\end{aligned}\tag{A.27}$$

since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, $E = E_0 + e_i + e_{-i}$, and $q_i = e_i$. The first order condition is given by:

$$\frac{\partial \tilde{\phi}_{LTCO}}{\partial q_i} = a - 2q_i - q_{-i} - c - t - \lambda_{INTRA}q_{-i} - \delta\gamma_{CO} = 0\tag{A.28}$$

and thus, whilst noting $\frac{\partial^2 \tilde{\phi}_{LTCO}}{\partial q_i^2} = -2 < 0$ so that the solution is a maximum, the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - (1 + \lambda_{INTRA})q_{-i} - c - t - \delta\gamma_{CO}}{2}.\tag{A.29}$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - c - t - \delta\gamma_{CO}}{3 + \lambda_{INTRA}},\tag{A.30}$$

where it is assumed $a > c + t + \delta\gamma_{CO}$ so that $q_i^* > 0$.

A.2.5 SRI

A Nash equilibrium is found by firm i choosing quantities, q_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned}\phi_{SRI} &= \pi_{Q,i} - \delta\gamma_{SRI}E \\ &= (a - q_i - q_{-i} - \tilde{c})q_i - \delta\gamma_f(E_0 + q_{-i}),\end{aligned}$$

where $\tilde{c} = c + t + \delta\gamma_{SRI}$, and since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, $E = E_0 + e_i + e_{-i}$, and $q_i = e_i$. The first order condition is given by:

$$\frac{\partial \phi_{SRI}}{\partial q_i} = a - 2q_i - q_{-i} - \tilde{c} = 0\tag{A.31}$$

and thus, whilst noting $\frac{\partial^2 \phi_{SRI}}{\partial q_i^2} = -2 < 0$ so that the solution is a maximum, the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - q_{-i} - \tilde{c}}{2}. \quad (\text{A.32})$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - \tilde{c}}{3} = \frac{a - c - t - \delta\gamma_{SRI}}{3}, \quad (\text{A.33})$$

where it is assumed $a > c + t + \delta\gamma_{SRI}$ so that $q_i^* > 0$.

A.2.6 Stakeholder-oriented shareholder

A.2.6.1 Equilibrium quantities

A Nash equilibrium is found by firm i choosing quantities, q_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned} \phi_S &= \pi_{Q,i} + \theta U_{cw}(Q, R_n, y) - \delta\gamma_S E \\ &= (a - q_i - q_{-i} - c)q_i - te_i \\ &\quad + \theta(y + aQ - \frac{Q^2}{2} + \sum_n aR_n - \frac{R_n^2}{2}) \\ &\quad - \delta\gamma_S E \\ &= (a - q_i - q_{-i} - \tilde{c})q_i \\ &\quad + \theta(wL - p_Q Q - \sum_n p_{R_n} R_n + aQ - \frac{Q^2}{2} + \sum_n aR_n - \frac{R_n^2}{2}) \\ &\quad - \delta\gamma_S (E_0 + q_{-i}) \\ &= (a - q_i - q_{-i} - \tilde{c})q_i + \theta \frac{(q_i + q_{-i})^2}{2} \\ &\quad + \theta(wL + \sum_n \frac{R_n^2}{2}) \\ &\quad - \delta\gamma_S (E_0 + q_{-i}), \end{aligned} \quad (\text{A.34})$$

where $\tilde{c} = c + t + \delta\gamma_S$, assuming the budget constraint binds such that $y = wL - p_Q Q - \sum_n p_{R_n} R_n$, and since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, $E = E_0 + e_i + e_{-i}$, and $q_i = e_i$. The first order condition is given by:

$$\frac{\partial \phi_S}{\partial q_i} = a - 2q_i - q_{-i} - \tilde{c} + \theta(q_i + q_{-i}) = 0 \quad (\text{A.35})$$

and thus, whilst noting $\frac{\partial^2 \phi_{SRI}}{\partial q_i^2} = -2 + \theta < 0$ for any $0 < \theta \leq 1$ so that the solution is a maximum, the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - (1 - \theta)q_{-i} - \tilde{c}}{2 - \theta}. \quad (\text{A.36})$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - \tilde{c}}{3 - 2\theta} = \frac{a - c - t - \delta\gamma_S}{3 - 2\theta}, \quad (\text{A.37})$$

where it is assumed $a > c + t + \delta\gamma_S$ so that $q_i^* > 0$. Note that $0 < \theta \leq 1$ implies the denominator is always positive.

A.2.6.2 Conditions that ensure the quantity choice by the stakeholder-oriented shareholder is less than the quantity choice in the benchmark model

The following condition must be satisfied:

$$q_{i,S}^* < q_{i,BM}^* \implies \frac{a - c - t - \delta\gamma_S}{3 - 2\theta} < \frac{a - c - t}{3}. \quad (\text{A.38})$$

Rearranging:

$$3(a - c - t - \delta\gamma_S) < (3 - 2\theta)(a - c - t) \implies \delta\gamma_S > \theta Q_{BM}^* \implies \delta\gamma_f > \theta(Q_{BM}^* - \delta(\gamma - \gamma_f)), \quad (\text{A.39})$$

where $Q_{BM}^* = 2q_{BM}^*$, $\delta\gamma_S = \delta\gamma_f + \delta\theta(\gamma - \gamma_f)$ and $\gamma = NI\gamma_f + \gamma_{cw}$. Now this condition will always be true if $Q_{BM}^* - \delta(\gamma - \gamma_f) < 0$ since $\gamma_f > 0$. Assuming $Q_{BM}^* - \delta(\gamma - \gamma_f) > 0$ and rearranging for θ :

$$\theta < \frac{\delta\gamma_f}{Q_{BM}^* - \delta(\gamma - \gamma_f)}. \quad (\text{A.40})$$

Since $0 < \theta \leq 1$, this condition is always true if the right-hand side is greater than or equal to 1:

$$\frac{\delta\gamma_f}{Q_{BM}^* - \delta(\gamma - \gamma_f)} \geq 1 \implies Q_{BM}^* \leq \delta\gamma, \quad (\text{A.41})$$

noting that the implication follows only if $Q_{BM}^* - \delta(\gamma - \gamma_f) > 0$, which was assumed at the outset.

A.2.6.3 No conditions that ensure the quantity choice by the stakeholder-oriented shareholder is greater than the quantity choice in the benchmark model

The following condition must be satisfied:

$$q_{i,S}^* > q_{i,BM}^* \implies \frac{a - c - t - \delta\gamma_S}{3 - 2\theta} > \frac{a - c - t}{3}. \quad (\text{A.42})$$

Rearranging:

$$3(a-c-t-\delta\gamma_S) > (3-2\theta)(a-c-t) \implies \delta\gamma_S < \theta Q_{BM}^* \implies \delta\gamma_f < \theta(Q_{BM}^* - \delta(\gamma - \gamma_f)), \quad (\text{A.43})$$

where $Q_{BM}^* = 2q_{BM}^*$, $\delta\gamma_S = \delta\gamma_f + \delta\theta(\gamma - \gamma_f)$ and $\gamma = NI\gamma_f + \gamma_{cw}$. Now this condition will cannot be true if $Q_{BM}^* - \delta(\gamma - \gamma_f) < 0$ since $\gamma_f > 0$. Assuming $Q_{BM}^* - \delta(\gamma - \gamma_f) > 0$ and rearranging for θ :

$$\theta > \frac{\delta\gamma_f}{Q_{BM}^* - \delta(\gamma - \gamma_f)}. \quad (\text{A.44})$$

Since $0 < \theta \leq 1$, this condition is always true if the right-hand side is less than or equal to 0:

$$\frac{\delta\gamma_f}{Q_{BM}^* - \delta(\gamma - \gamma_f)} \leq 0 \implies \delta\gamma_f \leq 0, \quad (\text{A.45})$$

which contradicts $\gamma_f > 0$. Thus there are no conditions that guarantee the stakeholder-oriented shareholder chooses a higher level of quantities than the choice in the benchmark model.

A.3 Models for Section 2.3

A.3.1 The benchmark mitigation-adaptation model

A Nash equilibrium is found by firm i choosing quantities, q_i , mitigation, m_i , and adaptation, a_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned}\phi_{STP} &= \pi_{Q,i} \\ &= (p_Q - c)q_i - te_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \\ &= (a - q_i - q_{-i} - c - t)q_i + tm_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2}\end{aligned}\quad (\text{A.46})$$

since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, and $e_i = q_i - m_i$. The first order condition with respect to q_i is given by:

$$\frac{\partial \phi_{STP}}{\partial q_i} = a - 2q_i - q_{-i} - c - t = 0 \quad (\text{A.47})$$

and thus the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - q_{-i} - c - t}{2}. \quad (\text{A.48})$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - c - t}{3}, \quad (\text{A.49})$$

where it is assumed $a > c + t$ so that $q_i^* > 0$. The first order condition with respect to m_i is given by:

$$\frac{\partial \phi_{STP}}{\partial m_i} = t - \rho m_i = 0 \quad (\text{A.50})$$

and thus equilibrium mitigation is given by:

$$m_i^* = \frac{t}{\rho}. \quad (\text{A.51})$$

The first order condition with respect to a_i is given by:

$$\frac{\partial \phi_{STP}}{\partial a_i} = -\nu a_i = 0 \quad (\text{A.52})$$

and thus equilibrium adaptation is given by:

$$a_i^* = 0. \quad (\text{A.53})$$

Finally, note that the Hessian matrix is given by:

$$H(q_i, m_i, a_i) = \begin{pmatrix} -2 & 0 & 0 \\ 0 & -\rho & 0 \\ 0 & 0 & -\nu \end{pmatrix}, \quad (\text{A.54})$$

which is negative definite at (q_i^*, m_i^*, a_i^*) . Therefore (q_i^*, m_i^*, a_i^*) is a maximum. Since it is unique and the objective function is concave, it is the global maximum.

A.3.2 Long-term profit maximizer with mitigation and adaptation

A Nash equilibrium is found by firm i choosing quantities, q_i , mitigation, m_i , and adaptation, a_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned} \phi_{LTP} &= \tilde{\pi}_{Q,i} \\ &= \pi_{Q,i} - \delta\gamma_f(E - a_i) \\ &= (p_Q - c)q_i - te_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} - \delta\gamma_f(E - a_i) \\ &= (a - q_i - q_{-i} - \tilde{c})q_i + (t + \delta\gamma_f)m_i + \delta\gamma_f a_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} - \delta\gamma_f(E_0 + q_{-i}), \end{aligned} \quad (\text{A.55})$$

where $\tilde{c} = c + t + \delta\gamma_f$, and since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, $E = E_0 + e_i + e_{-i}$, and $e_i = q_i - m_i$. The first order condition for quantities is given by:

$$\frac{\partial \phi_{LTP}}{\partial q_i} = a - 2q_i - q_{-i} - \tilde{c} = 0 \quad (\text{A.56})$$

and thus the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - q_{-i} - \tilde{c}}{2}. \quad (\text{A.57})$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - \tilde{c}}{3} = \frac{a - c - t - \delta\gamma_f}{3}, \quad (\text{A.58})$$

where it is assumed $a > c + t + \delta\gamma_f$ so that $q_i^* > 0$. The first order condition with respect to m_i is given by:

$$\frac{\partial \phi_{LTP}}{\partial m_i} = t + \delta\gamma_f - \rho m_i = 0 \quad (\text{A.59})$$

and thus equilibrium mitigation is given by:

$$m_i^* = \frac{t + \delta\gamma_f}{\rho}. \quad (\text{A.60})$$

The first order condition with respect to a_i is given by:

$$\frac{\partial \phi_{LTP}}{\partial m_i} = \delta \gamma_f - \nu a_i = 0 \quad (\text{A.61})$$

and thus equilibrium adaptation is given by:

$$a_i^* = \frac{\delta \gamma_f}{\nu}. \quad (\text{A.62})$$

Finally, note that the Hessian matrix is given by:

$$H(q_i, m_i, a_i) = \begin{pmatrix} -2 & 0 & 0 \\ 0 & -\rho & 0 \\ 0 & 0 & -\nu \end{pmatrix}, \quad (\text{A.63})$$

which is negative definite at (q_i^*, m_i^*, a_i^*) . Therefore (q_i^*, m_i^*, a_i^*) is a maximum. Since it is unique and the objective function is concave, it is the global maximum.

A.3.3 Short-term common owner with mitigation and adaptation

A Nash equilibrium is found by firm i choosing quantities, q_i , mitigation, m_i , and adaptation, a_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned} \tilde{\phi}_{STCO} &= \pi_{Q,i} + \lambda_{INTRA,Q} \pi_{Q,-i} \\ &\quad + \sum_n \lambda_{INTER,R_n} (\pi_{R_n,i} + \lambda_{INTRA,R_n} \pi_{R_n,-i}) \\ &\quad - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \\ &= (a - q_i - q_{-i} - c - t)(q_i + \lambda_{INTRA,Q} q_{-i}) + t m_i \\ &\quad + \sum_n \lambda_{INTER,R_n} (\pi_{R_n,i} + \lambda_{INTRA,R_n} \pi_{R_n,-i}) \\ &\quad - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \end{aligned} \quad (\text{A.64})$$

since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, and $e_i = q_i - m_i$. The first order condition is given by:

$$\frac{\partial \tilde{\phi}_{STCO}}{\partial q_i} = a - 2q_i - q_{-i} - c - t - \lambda_{INTRA} q_{-i} = 0 \quad (\text{A.65})$$

and thus the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - (1 + \lambda_{INTRA})q_{-i} - c - t}{2}. \quad (\text{A.66})$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - c - t}{3 + \lambda_{INTRA}}, \quad (\text{A.67})$$

where it is assumed $a > c + t$ so that $q_i^* > 0$. The first order condition with respect to m_i is given by:

$$\frac{\partial \tilde{\phi}_{STCO}}{\partial m_i} = t - \rho m_i = 0 \quad (\text{A.68})$$

and thus equilibrium mitigation is given by:

$$m_i^* = \frac{t}{\rho}. \quad (\text{A.69})$$

The first order condition with respect to a_i is given by:

$$\frac{\partial \tilde{\phi}_{STCO}}{\partial a_i} = -\nu a_i = 0 \quad (\text{A.70})$$

and thus equilibrium adaptation is given by:

$$a_i^* = 0. \quad (\text{A.71})$$

Finally, note that the Hessian matrix is given by:

$$H(q_i, m_i, a_i) = \begin{pmatrix} -2 & 0 & 0 \\ 0 & -\rho & 0 \\ 0 & 0 & -\nu \end{pmatrix}, \quad (\text{A.72})$$

which is negative definite at (q_i^*, m_i^*, a_i^*) . Therefore (q_i^*, m_i^*, a_i^*) is a maximum. Since it is unique and the objective function is concave, it is the global maximum.

A.3.4 Long-term common owner with mitigation and adaptation

A Nash equilibrium is found by firm i choosing quantities, q_i , mitigation, m_i , and adaptation, a_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned}
\tilde{\phi}_{LTCO} &= \pi_{Q,i} + \lambda_{INTRA,Q}\pi_{Q,-i} + \sum_n \lambda_{INTER,R_n}(\pi_{R_n,i} + \lambda_{INTRA,R_n}\pi_{R_n,-i}) \\
&\quad - \delta\gamma_f(E - a_i) - \delta(\gamma_{CO} - \gamma_f)E \\
&= (a - q_i - q_{-i} - c)q_i - te_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \\
&\quad + \lambda_{INTRA,Q}((a - q_i - q_{-i} - c)q_{-i} - te_{-i} - \frac{\rho m_{-i}^2}{2} - \frac{\nu a_{-i}^2}{2}) \\
&\quad + \sum_n \lambda_{INTER,R_n}(\pi_{R_n,i} + \lambda_{INTRA,R_n}\pi_{R_n,-i}) \\
&\quad - \delta\gamma_f(E - a_i) - \delta(\gamma_{CO} - \gamma_f)E \\
&= (a - q_i - q_{-i} - c - t)(q_i + \lambda_{INTRA,Q}q_{-i}) - \delta\gamma_{CO}q_i \\
&\quad + (t + \delta\gamma_{CO})m_i + \delta\gamma_f a_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \\
&\quad + \lambda_{INTRA,Q}(tm_{-i} - \frac{\rho m_{-i}^2}{2} - \frac{\nu a_{-i}^2}{2}) \\
&\quad + \sum_n \lambda_{INTER,R_n}(\pi_{R_n,i} + \lambda_{INTRA,R_n}\pi_{R_n,-i}) \\
&\quad - \delta\gamma_f(E_0 + q_{-i}) - \delta(\gamma_{CO} - \gamma_f)(E_0 + q_{-i})
\end{aligned} \tag{A.73}$$

since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, $E = E_0 + e_i + e_{-i}$, and $e_i = q_i - m_i$. The first order condition is given by:

$$\frac{\partial \tilde{\phi}_{LTCO}}{\partial q_i} = a - 2q_i - q_{-i} - c - t - \lambda_{INTRA}q_{-i} - \delta\gamma_{CO} = 0 \tag{A.74}$$

and thus the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - (1 + \lambda_{INTRA})q_{-i} - c - t - \delta\gamma_{CO}}{2}. \tag{A.75}$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - c - t - \delta\gamma_{CO}}{3 + \lambda_{INTRA}}. \tag{A.76}$$

where it is assumed $a > c + t + \delta\gamma_{CO}$ so that $q_i^* > 0$. The first order condition with respect to m_i is given by:

$$\frac{\partial \tilde{\phi}_{LTCO}}{\partial m_i} = t + \delta\gamma_{CO} - \rho m_i = 0 \tag{A.77}$$

and thus equilibrium mitigation is given by:

$$m_i^* = \frac{t + \delta\gamma_{CO}}{\rho}. \quad (\text{A.78})$$

The first order condition with respect to a_i is given by:

$$\frac{\partial \tilde{\phi}_{LTP}}{\partial m_i} = \delta\gamma_f - \nu a_i = 0 \quad (\text{A.79})$$

and thus equilibrium adaptation is given by:

$$a_i^* = \frac{\delta\gamma_f}{\nu}. \quad (\text{A.80})$$

Finally, note that the Hessian matrix is given by:

$$H(q_i, m_i, a_i) = \begin{pmatrix} -2 & 0 & 0 \\ 0 & -\rho & 0 \\ 0 & 0 & -\nu \end{pmatrix}, \quad (\text{A.81})$$

which is negative definite at (q_i^*, m_i^*, a_i^*) . Therefore (q_i^*, m_i^*, a_i^*) is a maximum. Since it is unique and the objective function is concave, it is the global maximum.

A.3.5 SRI with mitigation and adaptation

A Nash equilibrium is found by firm i choosing quantities, q_i , mitigation, m_i , and adaptation, a_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned} \phi_{SRI} &= \pi_{Q,i} - \delta\gamma_f(E - a_i) - \delta(\gamma_{SRI} - \gamma_f)E \\ &= (a - q_i - q_{-i} - \tilde{c})q_i + (t + \delta\gamma_{SRI})m_i + \delta\gamma_f a_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \\ &\quad - \delta\gamma_f(E_0 + q_{-i}) - \delta(\gamma_{SRI} - \gamma_f)(E_0 + q_{-i}), \end{aligned} \quad (\text{A.82})$$

where $\tilde{c} = c + t + \delta\gamma_{SRI}$, and since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, $E = E_0 + e_i + e_{-i}$, and $q_i = e_i - m_i$. The first order condition is given by:

$$\frac{\partial \phi_{SRI}}{\partial q_i} = a - 2q_i - q_{-i} - \tilde{c} = 0 \quad (\text{A.83})$$

and thus the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - q_{-i} - \tilde{c}}{2}. \quad (\text{A.84})$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - \tilde{c}}{3} = \frac{a - c - t - \delta\gamma_{SRI}}{3}, \quad (\text{A.85})$$

where it is assumed $a > c + t + \delta\gamma_{SRI}$ so that $q_i^* > 0$. The first order condition with respect to m_i is given by:

$$\frac{\partial\phi_{SRI}}{\partial m_i} = t + \delta\gamma_{SRI} - \rho m_i = 0 \quad (\text{A.86})$$

and thus equilibrium mitigation is given by:

$$m_i^* = \frac{t + \delta\gamma_{SRI}}{\rho}. \quad (\text{A.87})$$

The first order condition with respect to a_i is given by:

$$\frac{\partial\phi_{SRI}}{\partial a_i} = \delta\gamma_f - \nu a_i = 0 \quad (\text{A.88})$$

and thus equilibrium adaptation is given by:

$$a_i^* = \frac{\delta\gamma_f}{\nu}. \quad (\text{A.89})$$

Finally, note that the Hessian matrix is given by:

$$H(q_i, m_i, a_i) = \begin{pmatrix} -2 & 0 & 0 \\ 0 & -\rho & 0 \\ 0 & 0 & -\nu \end{pmatrix}, \quad (\text{A.90})$$

which is negative definite at (q_i^*, m_i^*, a_i^*) . Therefore (q_i^*, m_i^*, a_i^*) is a maximum. Since it is unique and the objective function is concave, it is the global maximum.

A.3.6 Stakeholder-oriented shareholder

A.3.6.1 Equilibrium quantities, mitigation and adaptation

A Nash equilibrium is found by firm i choosing quantities, q_i , mitigation, m_i , and adaptation, a_i , taking the other firm's quantities, q_{-i} , as given to maximise:

$$\begin{aligned}
\phi_S &= \pi_{Q,i} + \theta U_{cw}(Q, R_n, y) - \delta\gamma_f(E - a_i) - \delta(\gamma_S - \gamma_f)E \\
&= (a - q_i - q_{-i} - c)q_i - te_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \\
&\quad + \theta(y + aQ - \frac{Q^2}{2} + \sum_n aR_n - \frac{R_n^2}{2}) \\
&\quad - \delta\gamma_f(E - a_i) - \delta(\gamma_S - \gamma_f)E \\
&= (a - q_i - q_{-i} - \tilde{c})q_i + (t + \delta\gamma_S)m_i + \delta\gamma_f a_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \\
&\quad + \theta(wL - p_Q Q - \sum_n p_{R_n} R_n + aQ - \frac{Q^2}{2} + \sum_n aR_n - \frac{R_n^2}{2}) \\
&\quad - \delta\gamma_f(E_0 + q_{-i}) - \delta(\gamma_S - \gamma_f)(E_0 + q_{-i}) \\
&= (a - q_i - q_{-i} - \tilde{c})q_i + \theta \frac{(q_i + q_{-i})^2}{2} + (t + \delta\gamma_S)m_i + \delta\gamma_f a_i - \frac{\rho m_i^2}{2} - \frac{\nu a_i^2}{2} \\
&\quad + \theta(wL + \sum_n \frac{R_n^2}{2}) \\
&\quad - \delta\gamma_f(E_0 + q_{-i}) - \delta(\gamma_S - \gamma_f)(E_0 + q_{-i}),
\end{aligned} \tag{A.91}$$

where $\tilde{c} = c + t + \delta\gamma_S$, assuming the budget constraint binds such that $y = wL - p_Q Q - \sum_n p_{R_n} R_n$, and since $p_Q = a - Q = a - q_i - q_{-i}$ and $a > Q$ so that $p_Q > 0$, $E = E_0 + e_i + e_{-i}$, and $e_i = q_i - m_i$. The first order condition for quantities is given by:

$$\frac{\partial \phi_S}{\partial q_i} = a - 2q_i - q_{-i} - \tilde{c} + \theta(q_i + q_{-i}) = 0 \tag{A.92}$$

and thus the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - (1 - \theta)q_{-i} - \tilde{c}}{2 - \theta}. \tag{A.93}$$

By noting the symmetry of firms implies $q_i^* = q_{-i}^*$, equilibrium quantity is given by:

$$q_i^* = \frac{a - \tilde{c}}{3 - 2\theta} = \frac{a - c - t - \delta\gamma_S}{3 - 2\theta}, \tag{A.94}$$

where it is assumed $a > c + t + \delta\gamma_S$ so that $q_i^* > 0$. Note that $0 < \theta \leq 1$ implies the denominator is always positive. The first order condition with respect to m_i is given by:

$$\frac{\partial \phi_S}{\partial m_i} = t + \delta\gamma_S - \rho m_i = 0 \quad (\text{A.95})$$

and thus equilibrium mitigation is given by:

$$m_i^* = \frac{t + \delta\gamma_S}{\rho}. \quad (\text{A.96})$$

The first order condition with respect to a_i is given by:

$$\frac{\partial \phi_S}{\partial a_i} = \delta\gamma_f - \nu a_i = 0 \quad (\text{A.97})$$

and thus equilibrium adaptation is given by:

$$a_i^* = \frac{\delta\gamma_f}{\nu}. \quad (\text{A.98})$$

Finally, note that the Hessian matrix is given by:

$$H(q_i, m_i, a_i) = \begin{pmatrix} -2 + \theta & 0 & 0 \\ 0 & -\rho & 0 \\ 0 & 0 & -\nu \end{pmatrix}, \quad (\text{A.99})$$

which is negative definite at (q_i^*, m_i^*, a_i^*) . Therefore (q_i^*, m_i^*, a_i^*) is a maximum. Since it is unique and the objective function is concave, it is the global maximum.

A.3.6.2 Conditions that ensure the emissions by the stakeholder-oriented shareholder are less than the emissions in the benchmark model

The following condition must be satisfied:

$$q_{i,S}^* - m_{i,S}^* < q_{i,BMAM}^* - m_{i,BMAM}^* \implies q_{i,S}^* - q_{i,BMAM}^* < m_{i,S}^* - m_{i,BMAM}^*. \quad (\text{A.100})$$

Substituting and rearranging:

$$\begin{aligned} \frac{a - c - t - \delta\gamma_S}{3 - 2\theta} - \frac{a - c - t}{3} &< \frac{t + \delta\gamma_S}{\rho} - \frac{t}{\rho} \\ \implies \frac{3(a - c - t - \delta\gamma_S) - (3 - 2\theta)(a - c - t)}{3(3 - 2\theta)} &< \frac{\delta\gamma_S}{\rho}. \end{aligned} \quad (\text{A.101})$$

Thus:

$$\frac{\theta(Q_{BMAM}^* - \delta(\gamma - \gamma_f)) - \delta\gamma_f}{3 - 2\theta} < \frac{\delta\gamma_S}{\rho}, \quad (\text{A.102})$$

where $Q_{BMAM}^* = 2q_{BMAM}^*$, $\delta\gamma_S = \delta\gamma_f + \delta\theta(\gamma - \gamma_f)$ and $\gamma = NI\gamma_f + \gamma_{cw}$.

The condition to ensure emissions for the stakeholder-oriented shareholder are higher than in the benchmark model is then the converse of the above condition.

A.3.6.3 Conditions that ensure the emissions by the stakeholder-oriented shareholder are less than the emissions in the benchmark model when firms are not exposed to damage from emissions

The following condition must be satisfied for a decrease in emissions:

$$q_{i,S}^* - m_{i,S}^* < q_{i,BMAM}^* - m_{i,BMAM}^* \implies q_{i,S}^* - q_{i,BMAM}^* < m_{i,S}^* - m_{i,BMAM}^*, \quad (\text{A.103})$$

which is the same as Appendix A.3.6.2. Substituting $\delta\gamma_Q = 0$:

$$\frac{\theta(Q_{BMAM}^* - \delta\gamma)}{3 - 2\theta} < \frac{\theta\delta\gamma}{\rho} \implies \theta \left(\frac{Q_{BMAM}^* - \delta\gamma}{3 - 2\theta} - \frac{\delta\gamma}{\rho} \right) < 0, \quad (\text{A.104})$$

where $Q_{BMAM}^* = 2q_{BMAM}^*$, $\delta\gamma_S = \delta\gamma_f + \delta\theta(\gamma - \gamma_f)$ and $\gamma = NI\gamma_f + \gamma_{cw}$. Since $\theta > 0$, for the condition to hold it must be that:

$$\frac{Q_{BMAM}^* - \delta\gamma}{3 - 2\theta} - \frac{\delta\gamma}{\rho} < 0 \implies \theta < \frac{3}{2} - \frac{Q_{BMAM}^* - \delta\gamma}{2\frac{\delta\gamma}{\rho}}. \quad (\text{A.105})$$

Since $0 < \theta \leq 1$, this is always true if the right-side is greater than or equal to 1:

$$\frac{3}{2} - \frac{Q_{BMAM}^* - \delta\gamma}{2\frac{\delta\gamma}{\rho}} \geq 1 \implies Q_{BMAM}^* - \delta\gamma < \frac{\delta\gamma}{\rho}. \quad (\text{A.106})$$

Thus, if this condition holds, then the stakeholder-oriented shareholder is guaranteed to reduce emissions. Following similar lines of reasoning, the following condition must hold for an increase in emissions:

$$\theta > \frac{3}{2} - \frac{Q_{BMAM}^* - \delta\gamma}{2\frac{\delta\gamma}{\rho}}. \quad (\text{A.107})$$

Since $0 < \theta \leq 1$, this is always true if the right-side is less than 0:

$$\frac{3}{2} - \frac{Q_{BMAM}^* - \delta\gamma}{2\frac{\delta\gamma}{\rho}} < 0 \implies Q_{BMAM}^* - \delta\gamma > 3\frac{\delta\gamma}{\rho}. \quad (\text{A.108})$$

Thus, if this condition holds, then the stakeholder-oriented shareholder is guaranteed to increase emissions.

A.3.7 Separating the long-term common owner and the SRI

A.3.7.1 The equilibrium revenue maximization point and conditions under which the point is less than the equilibrium quantities in the benchmark model

Equilibrium revenue for firm i in the benchmark mitigation-adaptation model is given by:

$$p_Q^* q_i^* = (a - 2q_i^*) q_i^* \quad (\text{A.109})$$

since $q_i^* = q_{-i}^*$. The first-order condition for the equilibrium quantity that maximises equilibrium revenue (the 'equilibrium revenue maximization point') is given by:

$$a - 4q_i^* = 0 \implies q_{i,RevMax}^* = \frac{a}{4}, \quad (\text{A.110})$$

noting that the second derivative is negative so $q_{i,RevMax}^*$ is indeed a maximum. Now, the equilibrium quantities from the benchmark model, $q_{i,BMAM}$, will be greater than the amount that maximises revenue, $q_{i,RevMax}$, if:

$$q_{i,RevMax}^* < q_{i,BMAM}^* \implies \frac{a}{4} < \frac{a - c - t}{3} \implies a > 4(c + t). \quad (\text{A.111})$$

Thus, if $a > 4(c + t)$, then equilibrium quantities in the benchmark model will be to the right of the equilibrium quantity that maximises revenue..

A.3.7.2 The benchmark-model-equivalent revenue point

Assuming $a > 4(c + t)$, the benchmark-model-equivalent revenue point can be found by noting that the revenue curve is symmetric, and therefore the distance between the benchmark-model-equivalent revenue point and the equilibrium revenue maximization point must be equal to the distance between the equilibrium revenue maximization point and the benchmark model equilibrium firm-level quantities. The distance between benchmark model equilibrium firm-level quantities and the equilibrium revenue maximization point is given by:

$$\frac{a - c - t}{3} - \frac{a}{4} = \frac{a - 4(c + t)}{12}. \quad (\text{A.112})$$

Therefore, the equivalent revenue point is given by:

$$q_{i,ERP}^* = \frac{a}{4} - \frac{a - 4(c + t)}{12} = \frac{a + 2(c + t)}{6}. \quad (\text{A.113})$$

A.3.7.3 No decrease in revenue for the SRI

The SRI will not decrease revenue if the SRI's equilibrium quantities are greater than or equal to the equivalent equilibrium revenue point:

$$q_{i,SRI}^* \geq q_{i,ERP}^* \implies \frac{a - c - t - \delta\gamma_{SRI}}{3} \geq \frac{a + 2(c + t)}{6} \implies \beta \leq \frac{a - 2\delta\gamma_f - 4(c + t)}{2\delta(\gamma - \gamma_f)}. \quad (\text{A.114})$$

Since $0 < \beta \leq 1$, the latter condition always holds if the right hand side is greater than or equal to 1:

$$\frac{a - 2\delta\gamma_f - 4(c + t)}{2\delta(\gamma - \gamma_f)} \geq 1 \implies a \geq 4(c + t) + 2\delta\gamma. \quad (\text{A.115})$$

Thus, the SRI will not decrease revenue if $a \geq 4(c + t) + 2\delta\gamma$.

A.3.7.4 Decrease in revenue for the LTCO in terms of inter-industry common ownership

The long-term common owner will decrease revenue if the long-term common owner's equilibrium quantities are less than the equivalent equilibrium revenue point:

$$q_{i,LTCO}^* < q_{i,ERP}^* \implies \frac{a - c - t - \delta\gamma_{CO}}{3 + \lambda_{INTRA}} < \frac{a + 2(c + t)}{6}, \quad (\text{A.116})$$

which implies:

$$\lambda_{INTRA} > \frac{3a - 12(c + t) - 6\delta\gamma_f(1 + \lambda_{INTER})}{a + 2(c + t) + 6\delta\gamma_f(1 + \lambda_{INTER})}. \quad (\text{A.117})$$

Since $0 < \lambda_{INTRA} < 1$, the latter condition always holds if the right hand side is less than or equal to 0:

$$\frac{3a - 12(c + t) - 6\delta\gamma_f(1 + \lambda_{INTER})}{a + 2(c + t) + 6\delta\gamma_f(1 + \lambda_{INTER})} \leq 0 \implies a \leq 4(c + t) + 2\delta\gamma_f(1 + \lambda_{INTER}). \quad (\text{A.118})$$

A.3.7.5 Conditions separating the long-term common owner and SRI in terms of inter-industry common ownership

The SRI will not decrease revenue if $a \geq 4(c + t) + 2\delta_{SRI}\gamma$. The long-term common owner will decrease revenue if $a \leq 4(c + t) + 2\delta_{LTCO}\gamma_f(1 + \lambda_{INTER})$ for any $0 < \lambda_{INTRA} < 1$. Therefore, the SRI will not decrease revenue and the long-term common owner will decrease revenue if:

$$4(c + t) + 2\delta_{SRI}\gamma \leq a \leq 4(c + t) + 2\delta_{LTCO}\gamma_f(1 + \lambda_{INTER}) \implies \lambda_{INTER} \geq \frac{\delta_{SRI}}{\delta_{LTCO}} \frac{\gamma}{\gamma_f} - 1. \quad (\text{A.119})$$

Thus, if $a \geq 4(c + t) + 2\delta_{SRI}\gamma$ and $\lambda_{INTER} \geq \frac{\delta_{SRI}\gamma}{\delta_{LTCO}\gamma_f} - 1$, then the SRI does not decrease revenue and the long-term common owner with any $0 < \lambda_{INTRA} < 1$ does decrease revenue.

A.3.7.6 Decrease in revenue for the LTCO in terms of intra-industry common ownership

The long-term common owner will decrease revenue if the long-term common owner's equilibrium quantities are less than the equivalent equilibrium revenue point:

$$q_{i,LTCO}^* < q_{i,ERP}^* \implies \frac{a - c - t - \delta\gamma_{CO}}{3 + \lambda_{INTRA}} < \frac{a + 2(c + t)}{6}, \quad (\text{A.120})$$

which implies:

$$\lambda_{INTER} > \frac{3a - 12(c + t) - 6\delta\gamma_f(1 + \lambda_{INTRA}) - \lambda_{INTRA}(a + 2(c + t))}{6\delta\gamma_f(1 + \lambda_{INTRA})}. \quad (\text{A.121})$$

Since $\lambda_{INTER} > 0$, this condition is always true if the right hand side is less than or equal to 0:

$$\frac{3a - 12(c + t) - 6\delta\gamma_f(1 + \lambda_{INTRA}) - \lambda_{INTRA}(a + 2(c + t))}{6\delta\gamma_f(1 + \lambda_{INTRA})} \leq 0, \quad (\text{A.122})$$

which implies:

$$3a - 12(c + t) - 6\delta\gamma_f(1 + \lambda_{INTRA}) - \lambda_{INTRA}(a + 2(c + t)) \leq 0 \quad (\text{A.123})$$

$$\implies (3 - \lambda_{INTRA})a - 2(6 + \lambda_{INTRA})(c + t) - 6\delta\gamma_f(1 + \lambda_{INTRA}) \leq 0 \quad (\text{A.124})$$

$$\implies a \leq \frac{2(6 + \lambda_{INTRA})(c + t) + 6\delta\gamma_f(1 + \lambda_{INTRA})}{3 - \lambda_{INTRA}}. \quad (\text{A.125})$$

A.3.7.7 Conditions separating the long-term common owner and SRI in terms of intra-industry common ownership

The SRI will not decrease revenue if $a \geq 4(c + t) + 2\delta_{SRI}\gamma$. The long-term common owner will decrease revenue if $a \leq \frac{2(6 + \lambda_{INTRA})(c + t) + 6\delta\gamma_f(1 + \lambda_{INTRA})}{3 - \lambda_{INTRA}}$ for any $\lambda_{INTER} > 0$. Therefore, the SRI will not decrease revenue and the long-term common owner will decrease revenue if:

$$4(c + t) + 2\delta_{SRI}\gamma \leq a \leq \frac{2(6 + \lambda_{INTRA})(c + t) + 6\delta\gamma_f(1 + \lambda_{INTRA})}{3 - \lambda_{INTRA}}, \quad (\text{A.126})$$

which implies:

$$\lambda_{INTRA} \geq \frac{3(\delta_{SRI}\gamma - \delta_{LTCO}\gamma_f)}{3(c + t) + 3\delta_{LTCO}\gamma_f + \delta_{SRI}\gamma} \quad (\text{A.127})$$

$$= \frac{3(\delta_{SRI}\gamma - \delta_{LTCO}\gamma_f)}{3(\delta_{SRI}\gamma - \delta_{LTCO}\gamma_f) + 3(c + t) + 6\delta_{LTCO}\gamma_f - 2\delta_{SRI}\gamma}. \quad (\text{A.128})$$

Thus, if $a \geq 4(c + t) + 2\delta_{SRI}\gamma$ and $\lambda_{INTRA} \geq \frac{3(\delta_{SRI}\gamma - \delta_{LTCO}\gamma_f)}{3(\delta_{SRI}\gamma - \delta_{LTCO}\gamma_f) + 3(c + t) + 6\delta_{LTCO}\gamma_f - 2\delta_{SRI}\gamma}$, then the SRI does not decrease revenue and the long-term common owner with any $\lambda_{INTER} > 0$ does decrease revenue.

A.3.7.8 Decrease in revenue for the LTCO in terms of intra- and inter-industry common ownership

The long-term common owner will decrease revenue if the long-term common owner's equilibrium quantities are less than the equivalent equilibrium revenue point:

$$q_{i,LTCO}^* < q_{i,ERP}^* \implies \frac{a - c - t - \delta\gamma_{CO}}{3 + \lambda_{INTRA}} < \frac{a + 2(c + t)}{6}, \quad (\text{A.129})$$

which implies:

$$a < \frac{2(6 + \lambda_{INTRA})(c + t) + 6\delta\gamma_{CO}}{3 - \lambda_{INTRA}}. \quad (\text{A.130})$$

A.3.7.9 Conditions separating the long-term common owner and SRI in terms of intra- and inter-industry common ownership

The SRI will not decrease revenue if $a \geq 4(c + t) + 2\delta_{SRI}\gamma$. The long-term common owner will decrease revenue if $a < \frac{2(6 + \lambda_{INTRA})(c + t) + 6\delta\gamma_{CO}}{3 - \lambda_{INTRA}}$. Therefore, the SRI will not decrease revenue and the long-term common owner will decrease revenue if:

$$4(c + t) + 2\delta_{SRI}\gamma \leq a < \frac{2(6 + \lambda_{INTRA})(c + t) + 6\delta\gamma_{CO}}{3 - \lambda_{INTRA}} \quad (\text{A.131})$$

$$\implies \frac{3(\lambda_{INTRA}(c + t) + \delta_{LTCO}\gamma_{CO})}{3 - \lambda_{INTRA}} > \delta_{SRI}\gamma. \quad (\text{A.132})$$

Thus, if $a \geq 4(c + t) + 2\delta_{SRI}\gamma$ and $\frac{3(\lambda_{INTRA}(c + t) + \delta_{LTCO}\gamma_{CO})}{3 - \lambda_{INTRA}} > \delta_{SRI}\gamma$, then the SRI does not decrease revenue and the long-term common owner does decrease revenue.

A.3.7.10 Decrease in revenue for the LTCO for any level of common ownership

The long-term common owner will decrease revenue if the long-term common owner's equilibrium quantities are less than the equivalent equilibrium revenue point:

$$q_{i,LTCO}^* < q_{i,ERP}^* \implies \frac{a - c - t - \delta\gamma_{CO}}{3 + \lambda_{INTRA}} < \frac{a + 2(c + t)}{6}, \quad (\text{A.133})$$

which implies:

$$\lambda_{INTRA} > \frac{3a - 12(c + t) - 6\delta\gamma_f(1 + \lambda_{INTER})}{a + 2(c + t) + 6\delta\gamma_f(1 + \lambda_{INTER})} \quad (\text{A.134})$$

Since $0 < \lambda_{INTRA} < 1$, the latter condition always holds if the right hand side is less than or equal to 0:

$$\frac{3a - 12(c + t) - 6\delta\gamma_f(1 + \lambda_{INTER})}{a + 2(c + t) + 6\delta\gamma_f(1 + \lambda_{INTER})} \leq 0 \implies a \leq 4(c + t) + 2\delta\gamma_f(1 + \lambda_{INTER}). \quad (\text{A.135})$$

Thus, the long-term common owner will decrease revenue if $a \leq 4(c + t) + 2\delta\gamma_f(1 + \lambda_{INTER})$. That is, if:

$$\lambda_{INTER} \geq \frac{a - 4(c + t) - 2\delta\gamma_f}{2\delta\gamma_f}. \quad (\text{A.136})$$

Since $\lambda_{INTER} > 0$, this condition always holds if the right hand side is less than or equal to zero:

$$\frac{a - 4(c + t) - 2\delta\gamma_f}{2\delta\gamma_f} \leq 0 \implies a \leq 4(c + t) - 2\delta\gamma_f. \quad (\text{A.137})$$

A.3.7.11 Conditions separating the long-term common owner and SRI for any level of common ownership

The SRI will not decrease revenue if $a \geq 4(c + t) + 2\delta_{SRI}\gamma$. The long-term common owner will decrease revenue if $a \leq 4(c + t) + 2\delta_{LTCO}\gamma_f$ for any $0 < \lambda_{INTRA} < 1$ and any $\lambda_{INTER} > 0$. Therefore, the SRI will not decrease revenue and the long-term common owner will decrease revenue if:

$$4(c + t) + 2\delta_{SRI}\gamma \leq a \leq 4(c + t) + 2\delta_{LTCO}\gamma_f \implies \frac{\delta_{SRI}}{\delta_{LTCO}} \frac{\gamma}{\gamma_f} \leq 1. \quad (\text{A.138})$$

Thus, if $a \geq 4(c + t) + 2\delta_{SRI}\gamma$ and $\frac{\delta_{SRI}}{\delta_{LTCO}} \frac{\gamma}{\gamma_f} \leq 1$, then the SRI does not decrease revenue and the long-term common owner with any $0 < \lambda_{INTRA} < 1$ and any $\lambda_{INTER} > 0$ does decrease revenue.

A.3.8 Models and results for imperfectly competitive, commonly owned, exclusive suppliers

A.3.8.1 Best responses given prices from suppliers

Below we provide the working only for short-term profit maximizers, short-term common owners, long-term common owners and stakeholder-oriented shareholders since we only provide formal results for these types. To recover results for the long-term profit maximizer and socially responsible investor, simply adjust the marginal costs of the short-term profit maximizer and conduct similar working.

A.3.8.1.1 Short-term profit maximizers

Firms in the final goods sector take prices of intermediate goods set by suppliers as given and choose their supply of final goods and demand for intermediate goods such that constraint $q_i = s_j$. The objective of the short-term profit maximizer is given by:

$$\phi_{STP} = \pi_{Q,i} = (a - q_i - q_{-i} - c_F - t - \bar{p}_j)q_i = (a - q_i - q_{-i} - \tilde{c}_{F,STP} - \bar{p}_j)q_i$$

where $\tilde{c}_{F,STP} = c_F + t$. The first order condition is given by:

$$\frac{\partial \phi_{STP}}{\partial q_i} = a - 2q_i - q_{-i} - \tilde{c}_{F,STP} - \bar{p}_j = 0 \quad (\text{A.139})$$

and thus, whilst noting $\frac{\partial^2 \phi_{STP}}{\partial q_i^2} = -2 < 0$ so that the solution is a maximum, the best response function is given by:

$$R_i(q_{-i}) = q_i = \frac{a - q_{-i} - \tilde{c}_{F,STP} - \bar{p}_j}{2}. \quad (\text{A.140})$$

Through similar steps, the best response function for firm $-i$ is given by:

$$R_i(q_i) = q_{-i} = \frac{a - q_i - \tilde{c}_{F,STP} - \bar{p}_{-j}}{2}. \quad (\text{A.141})$$

It then follows that the best responses of firm i in Section Q given the prices of the supplying firms in Sector j is given by:

$$q_i^* = A_{STP} - B_{STP}\bar{p}_j + C_{STP}\bar{p}_{-j} \quad (\text{A.142})$$

where $A_{STP} = \frac{a - \tilde{c}_{F,STP}}{3}$, $B_{STP} = \frac{2}{3}$ and $C_{STP} = \frac{1}{3}$.

A.3.8.1.2 Short-term common owners

Firms in the final goods sector take prices of intermediate goods set by suppliers as given and choose their supply of final goods and demand for intermediate goods such that constraint $q_i = s_j$. The objective of the short-term profit maximizer is given by:

$$\tilde{\phi}_{STCO} = \pi_{Q,i} + \lambda_{INTRA,Q}\pi_{Q,-i} + \lambda_{INTER,S}\pi_{S,j} + \lambda_{INTER,S}\lambda_{INTRA,S}\pi_{S,-j} + R \quad (\text{A.143})$$

$$= (a - q_i - q_{-i} - \tilde{c}_{\lambda_{INTER,SQ}} - \tilde{p}_j)q_i + \lambda_{INTRA}(a - q_i - q_{-i} - \tilde{c}_{\lambda_{INTER,SQ}} - \tilde{p}_{-j})q_{-i} + R \quad (\text{A.144})$$

where $\tilde{c}_{F,STP} = c_F + t$, $\tilde{c}_{I,STP} = c_I + t$, $\tilde{c}_{\lambda_{INTER,SQ}} = \tilde{c}_{F,STP} + \lambda_{INTER,SQ}\tilde{c}_{I,STP}$, $\tilde{p}_j = (1 - \lambda_{INTER,SQ})\bar{p}_j$, $\lambda_{INTRA} = \lambda_{INTRA,Q} = \lambda_{INTRA,SQ}$. Solving the first order conditions for both firms, whilst noting $\frac{\partial \tilde{\phi}_{STCO}}{\partial q_i} = -2 < 0$ so that the solution is indeed a maximum, yields:

$$q_i^* = A_{STCO} - B_{STCO}\bar{p}_j + C_{STCO}\bar{p}_{-j} \quad (\text{A.145})$$

where $A_{STCO} = \frac{(a - \tilde{c}_{INTRA,S})}{3 + \lambda_{INTRA}}$, $B_{STCO} = \frac{2(1 - \lambda_{INTER,S})}{(3 + \lambda_{INTRA})(1 - \lambda_{INTRA})}$, $C_{STCO} = \frac{(1 + \lambda_{INTRA})(1 - \lambda_{INTER,S})}{(3 + \lambda_{INTRA})(1 - \lambda_{INTRA})}$.

A.3.8.1.3 Long-term common owners

Firms in the final goods sector take prices of intermediate goods set by suppliers as given and choose their supply of final goods and demand for intermediate goods such that constraint $q_i = s_j$. The objective of the short-term profit maximizer is given by:

$$\tilde{\phi}_{LTCO} = \tilde{\phi}_{STCO} - \delta\gamma_{LTCO}E \quad (\text{A.146})$$

$$= (a - q_i - q_{-i} - \tilde{c}_{LTCO} - \tilde{p}_j)q_i + \lambda_{INTRA}(a - q_i - q_{-i} - \tilde{c}_{LTCO} - \tilde{p}_{-j})q_{-i} \quad (\text{A.147})$$

$$+ \delta\gamma_{CO}(E_0 + 2(1 - \lambda_{INTRA})q_{-i}) + R \quad (\text{A.148})$$

where $\tilde{c}_{F,STP} = c_F + t$, $\tilde{c}_{I,STP} = c_I + t$, $\tilde{c}_{\lambda_{INTER,SQ}} = \tilde{c}_{F,STP} + \lambda_{INTER,SQ}\tilde{c}_{I,STP}$, $\tilde{c}_{LTCO} = \tilde{c}_{\lambda_{INTER,SQ}} + 2\delta\gamma_{CO}$, $\tilde{p}_j = (1 - \lambda_{INTER,SQ})\bar{p}_j$, $\lambda_{INTRA} = \lambda_{INTRA,Q} = \lambda_{INTRA,SQ}$. Solving the first order conditions for both firms, whilst noting $\frac{\partial\tilde{\phi}_{STCO}}{\partial q_i} = -2 < 0$ so that the solution is indeed a maximum, yields:

$$q_i^* = A_{LTCO} - B_{LTCO}\bar{p}_j + C_{LTCO}\bar{p}_{-j} \quad (\text{A.149})$$

where $A_{LTCO} = \frac{a - \tilde{c}_{LTCO}}{3 + \lambda_{INTRA}}$, $B_{LTCO} = \frac{2(1 - \lambda_{INTER,S})}{(3 + \lambda_{INTRA})(1 - \lambda_{INTRA})}$, $C_{LTCO} = \frac{(1 + \lambda_{INTRA})(1 - \lambda_{INTER,S})}{(3 + \lambda_{INTRA})(1 - \lambda_{INTRA})}$.

A.3.8.1.4 Stakeholder-oriented shareholders

Firms in the final goods sector take prices of intermediate goods set by suppliers as given and choose their supply of final goods and demand for intermediate goods such that constraint $q_i = s_j$. The objective of the short-term profit maximizer is given by:

$$\phi_S = \pi_{Q,i} + \theta\pi_{S,j} + \theta U_{cw}(Q, R_n, y) - \delta\gamma_S E \quad (\text{A.150})$$

$$= (a - q_i - q_{-i} - \tilde{c}_{F,S} - \tilde{p}_j) + \theta \left(\frac{(q_i + q_{-i})^2}{2} + wL + \sum_n aR_n - \frac{R_n^2}{2} - p_{R_n}R \right) + \delta\gamma_S E_0 + 2q_{-i} \quad (\text{A.151})$$

where $\tilde{c}_{F,S} = \tilde{c}_{F,STP} + \theta\tilde{c}_{I,STP} + 2\delta\gamma_S$ and $\tilde{p}_j = (1 - \theta)\bar{p}_j$. Solving the first order conditions for both firms, whilst noting $\frac{\partial\phi_{STCO}}{\partial q_i} = -2 + \theta < 0$ so that the solution is indeed a maximum, yields:

$$q_i^* = A_S - B_S\bar{p}_j + C_S\bar{p}_{-j} \quad (\text{A.152})$$

where $A_S = \frac{(a - \tilde{c}_{F,S})}{3 - 2\theta}$, $B_S = \frac{(2 - \theta)(1 - \theta)}{3 - 2\theta}$, $C_S = \frac{(1 - \theta)^2}{3 - 2\theta}$.

A.3.8.2 Comparison to STP

A.3.8.2.1 Short-term common owners

Given the results in Appendices A.3.8.1.1 and A.3.8.1.2, short-term common owner i reduces quantities relative to short-term profit maximizer i if and only if:

$$A_{STCO} - B_{STCO}\bar{p}_j + C_{STCO}\bar{p}_{-j} < A_{STP} - B_{STP}\bar{p}_j + C_{STP}\bar{p}_{-j} \quad (\text{A.153})$$

It can then be shown that if $\lambda_{INTRA} > \lambda_{INTRA}^* := \frac{2\bar{p}_j - \bar{p}_{-j} - \tilde{c}_{I,STP}}{\bar{p}_{-j} - \tilde{c}_{I,STP}}$, then above condition holds if and only if:

$$\lambda_{INTER,S} < \lambda_{INTER,S}^*(\lambda_{INTRA}) \quad (\text{A.154})$$

$$:= \frac{\lambda_{INTRA}(1 - \lambda_{INTRA})(a - \tilde{c}_{F,STP}) + \lambda_{INTRA}(4 + \lambda_{INTRA})\bar{p}_j + (3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2)\bar{p}_{-j}}{3(2\bar{p}_j - (1 + \lambda_{INTRA})\bar{p}_{-j} - (1 - \lambda_{INTRA})\tilde{c}_{I,STP})} \quad (\text{A.155})$$

Now note that $\lambda_{INTER,S}^*(\lambda_{INTRA}) > 0$ would imply that the above condition is not necessarily satisfied for all $\lambda_{INTER,S} > 0$. We now show that $\lambda_{INTER,S}^*(\lambda_{INTRA}) > 0$ by showing that, if $\lambda_{INTRA} > \lambda_{INTRA}^*$, it is not the case that $\lambda_{INTER,S}^*(\lambda_{INTRA}) < 0$. So suppose $\lambda_{INTRA} > \lambda_{INTRA}^*$ and $\lambda_{INTER,S}^*(\lambda_{INTRA}) < 0$. $\lambda_{INTER,S}^*(\lambda_{INTRA}) < 0$ implies that:

$$\bar{p}_j < \frac{(3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2)\bar{p}_{-j} - \lambda_{INTRA}(1 - \lambda_{INTRA})(a - \tilde{c}_{F,STP})}{\lambda_{INTRA}(4 + \lambda_{INTRA})} \quad (\text{A.156})$$

Note, since $a - \tilde{c}_{F,STP} > 0$ and $\lambda_{INTRA} > 0$, if $3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2 \leq 0$, which is true for $\lambda_{INTRA} \leq \frac{-7 + \sqrt{61}}{2} \approx 0.4$, the above cannot hold since the numerator is negative, the denominator is positive and $\bar{p}_j > 0$. Now consider the remaining region $1 > \lambda_{INTRA} > \frac{-7 + \sqrt{61}}{2}$ and note that $\lambda_{INTRA} > \lambda_{INTRA}^*$ implies

$$\bar{p}_j > \frac{(1 + \lambda_{INTRA})\bar{p}_{-j} + (1 - \lambda_{INTRA})\tilde{c}_{F,STP}}{2}. \quad (\text{A.157})$$

Combining this with the condition on \bar{p}_j derived from $\lambda_{INTER,S}^*(\lambda_{INTRA}) < 0$ implies that:

$$\frac{(3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2)\bar{p}_{-j} - \lambda_{INTRA}(1 - \lambda_{INTRA})(a - \tilde{c}_{F,STP})}{\lambda_{INTRA}(4 + \lambda_{INTRA})} \quad (\text{A.158})$$

$$> \frac{(1 + \lambda_{INTRA})\bar{p}_{-j} + (1 - \lambda_{INTRA})\tilde{c}_{F,STP}}{2}. \quad (\text{A.159})$$

Since $a - \tilde{c}_{F,STP} > 0$ and $\tilde{c}_{F,STP} > 0$, it follows that it must be that

$$\frac{(3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2)\bar{p}_{-j}}{\lambda_{INTRA}(4 + \lambda_{INTRA})} > \frac{(1 + \lambda_{INTRA})\bar{p}_{-j}}{2}. \quad (\text{A.160})$$

From which it can be shown that the following must be satisfied:

$$-\lambda_{INTRA}^3 - 3\lambda_{INTRA}^2 + 10\lambda_{INTRA} - 6 > 0 \quad (\text{A.161})$$

which does not hold in the region $1 > \lambda_{INTRA} > \frac{-7+\sqrt{61}}{2}$. Therefore, if $\lambda_{INTRA} > \lambda_{INTRA}^*$, then there is no λ_{INTRA} for which $\lambda_{INTER,S}^*(\lambda_{INTRA}) < 0$. Therefore, if $\lambda_{INTRA} > \lambda_{INTRA}^*$, $\lambda_{INTER,S}^* > 0$. Therefore, if $\lambda_{INTRA} > \lambda_{INTRA}^*$, there is no result that applies for all $\lambda_{INTER,S}^*(\lambda_{INTRA}) > 0$.

Now suppose $\lambda_{INTRA} < \lambda_{INTRA}^*$, then the short-term common owner i reduces quantities relative to short-term profit maximizer i if and only if $\lambda_{INTER,S} > \lambda_{INTER,S}^*(\lambda_{INTRA})$. $\lambda_{INTER,S} > \lambda_{INTER,S}^*(\lambda_{INTRA})$ will always hold if $\lambda_{INTER,S}^*(\lambda_{INTRA}) < 0$. Through similar working to above, however, now noting $\lambda_{INTRA} < \lambda_{INTRA}^*$, it can be shown that the following must therefore hold:

$$\bar{p}_j > \frac{(3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2)\bar{p}_{-j} - \lambda_{INTRA}(1 - \lambda_{INTRA})(a - \tilde{c}_{F,STP})}{\lambda_{INTRA}(4 + \lambda_{INTRA})} \quad (\text{A.162})$$

If $3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2 \leq 0$, which is true for $\lambda \leq \frac{-7+\sqrt{61}}{2} \approx 0.4$, for similar reasons to those given above, the left side of the above inequality is less than zero, and, therefore, since $\bar{p}_j > 0$, the above inequality holds. Now consider the case where $1 > \lambda > \frac{-7+\sqrt{61}}{2}$. By following previous steps to those in the proof for $\lambda_{INTRA} > \lambda_{INTRA}^*$, it can be shown that the following must hold:

$$\frac{(3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2)\bar{p}_{-j} - \lambda_{INTRA}(1 - \lambda_{INTRA})(a - \tilde{c}_{F,STP})}{\lambda_{INTRA}(4 + \lambda_{INTRA})} \quad (\text{A.163})$$

$$< \frac{(1 + \lambda_{INTRA})\bar{p}_{-j} + (1 - \lambda_{INTRA})\tilde{c}_{F,STP}}{2}, \quad (\text{A.164})$$

which can be more helpfully re-arranged to:

$$-\frac{\lambda_{INTRA}(1 - \lambda_{INTRA})(a - \tilde{c}_{F,STP})}{\lambda_{INTRA}(4 + \lambda_{INTRA})} - \frac{(1 - \lambda_{INTRA})\tilde{c}_{F,STP}}{2} \quad (\text{A.165})$$

$$< \frac{(1 + \lambda_{INTRA})\bar{p}_{-j}}{2} - \frac{(3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2)\bar{p}_{-j}}{\lambda_{INTRA}(4 + \lambda_{INTRA})} \quad (\text{A.166})$$

Note that, for $1 > \lambda_{INTRA} > 0$, the left-hand side takes its maximum value where $a - \tilde{c}_{F,STP} = 0$ and $\tilde{c}_{F,STP} = 0$. Therefore, if the above condition holds for $a - \tilde{c}_{F,STP} = 0$ and $\tilde{c}_{F,STP} = 0$, then it must hold for all $a - \tilde{c}_{F,STP} > 0$ and $\tilde{c}_{F,STP} > 0$. Substituting $a - \tilde{c}_{F,STP} = 0$ and $\tilde{c}_{F,STP} = 0$ into the above condition and rearranging yields:

$$-\lambda_{INTRA}^3 - 3\lambda_{INTRA}^2 + 10\lambda_{INTRA} - 6 < 0, \quad (\text{A.167})$$

which is true for all $1 > \lambda > \frac{-7+\sqrt{61}}{2}$. Therefore, if $\lambda_{INTRA} < \lambda_{INTRA}^*$, then $\lambda_{INTER,S}^*(\lambda_{INTRA}) <$

0. Therefore, if $\lambda_{INTRA} < \lambda_{INTRA}^*$, the short-term common owner always reduces quantities relative to the short-term profit maximizer.

A.3.8.2.2 Long-term common owners

Given the results in Appendices A.3.8.1.1 and A.3.8.1.3, long-term common owner i reduces quantities relative to short-term profit maximizer i if and only if:

$$A_{LTCO} - B_{LTCO}\bar{p}_j + C_{LTCO}\bar{p}_{-j} < A_{STP} - B_{STP}\bar{p}_j + C_{STP}\bar{p}_{-j}. \quad (A.168)$$

If $\lambda_{INTRA} < \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, the above condition holds when $\lambda_{INTER,S} < \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$, where:

$$\lambda_{INTRA}^*(\delta, \lambda_{INTRA}) := \frac{2\bar{p}_j - \bar{p}_{-j} - \tilde{c}_{I,STP} - 2\lambda_{INTRA}^2\delta\gamma_f}{\bar{p}_{-j} - \tilde{c}_{I,STP}} \quad (A.169)$$

$$\lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER}) \quad (A.170)$$

$$:= \frac{\lambda_{INTRA}(1 - \lambda_{INTRA})(a - \tilde{c}_{F,STP}) + \lambda_{INTRA}(4 + \lambda_{INTRA})\bar{p}_j + (3 - 7\lambda_{INTRA} - \lambda_{INTRA}^2)\bar{p}_{-j}}{3(2\bar{p}_j - (1 + \lambda_{INTRA})\bar{p}_{-j} - (1 - \lambda_{INTRA})\tilde{c}_{I,STP} - 2\delta\gamma_f(1 + \lambda_{INTRA})(1 - \lambda_{INTRA}))} \quad (A.171)$$

$$+ \frac{6(1 - \lambda_{INTRA})\delta(\gamma_{CO} - \lambda_{INTER,S}(1 + \lambda_{INTRA})\gamma_f)}{3(2\bar{p}_j - (1 + \lambda_{INTRA})\bar{p}_{-j} - (1 - \lambda_{INTRA})\tilde{c}_{I,STP} - 2\delta\gamma_f(1 + \lambda_{INTRA})(1 - \lambda_{INTRA}))} \quad (A.172)$$

If $\lambda_{INTRA} < \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, then by similar arguments to the short term common owner, the first term in $\lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$ is greater than zero. Also, the second term in $\lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$ is greater than zero. Therefore, if $\lambda_{INTRA} < \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, then the long-term common owner i reduces quantities relative to short-term profit maximizer i if and only if $\lambda_{INTER,S} < \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$.

If $\lambda_{INTRA} < \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, then the long-term common owner i reduces quantities relative to short-term profit maximizer i if and only if $\lambda_{INTER,S} > \lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$. In this, case both terms in $\lambda_{INTER,S}^*(\lambda_{INTRA}, \delta, \lambda_{INTER})$ are negative since the numerators have changed sign. Therefore $\lambda_{INTRA} < \lambda_{INTRA}^*(\delta, \lambda_{INTRA})$, then the long-term common owner i reduces quantities relative to short-term profit maximizer.

A.3.8.2.3 Stakeholder-oriented shareholders

Given the results in Appendices A.3.8.1.1 and A.3.8.1.4, stakeholder-oriented shareholder i reduces quantities relative to short-term profit maximizer i if and only if:

$$A_S - B_S\bar{p}_j + C_S\bar{p}_{-j} < A_{STP} - B_{STP}\bar{p}_j + C_{STP}\bar{p}_{-j}. \quad (A.173)$$

From this condition it can be shown that the following must hold:

$$2\delta\gamma_f > \theta(Q_{BM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j})) \quad (\text{A.174})$$

Now, if $Q_{BM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j}) < 0$, then above condition must hold since $2\delta\gamma_f > 0$. If $Q_{BM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j}) > 0$, then:

$$\theta < \theta^*(\delta, \theta) := \frac{2\delta\gamma_f}{Q_{BM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j})} \quad (\text{A.175})$$

Now where $Q_{BM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j}) > 0$, the above is always true if $\theta^*(\delta, \theta) \geq 1$, which implies:

$$Q_{BM}^* - 2\delta\gamma + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j}) < 0 \quad (\text{A.176})$$

For emissions to fall, the following condition must be satisfied:

$$q_{i,S}^* - m_{i,S}^* < q_{i,BMAM}^* - m_{i,BMAM}^* \implies q_{i,S}^* - q_{i,BMAM}^* < m_{i,S}^* - m_{i,BMAM}^*. \quad (\text{A.177})$$

Substituting and rearranging:

$$A_S - B_S\bar{p}_j + C_S\bar{p}_{-j} - A_{STP} - B_{STP}\bar{p}_j + C_{STP}\bar{p}_{-j} < \frac{t + \delta\gamma_S}{\rho} - \frac{t}{\rho}$$

Thus:

$$\frac{\theta(Q_{BM}^* - 2\delta(\gamma - \gamma_f) + (\bar{p}_j - c_{I,STP}) + (2 - \theta)(\bar{p}_j - \bar{p}_{-j})) - 2\delta\gamma_f}{3 - 2\theta} < \frac{\delta\gamma_S}{\rho}, \quad (\text{A.178})$$

where $Q_{BMAM}^* = 2q_{BMAM}^*$ and $\delta\gamma_S = \delta\gamma_f + \delta\theta(\gamma - \gamma_f)$.

The condition to ensure emissions for the stakeholder-oriented shareholder are higher than in the benchmark model is then the converse of the above condition.

A.4 Discussion and limitations

A.4.1 Further results assuming a common discount factor or common intra-industry incentive

Since some active ownership objectives contain more than one of the incentives above, if it is assumed that these incentives are identical across objectives, the following results also arise:

Proposition 18. *Assuming a common time discount factor, δ , quantities and emissions relative to the alternative where firms are long-term profit maximizers are:*

- i. *Lower for the long-term common owner for all intra-industry incentives $0 < \lambda_{INTRA} < 1$ and inter-industry incentives $\lambda_{INTER} > 0$; and*
- ii. *Lower for the SRI for all SRI discount factors $0 < \beta \leq 1$.*

Proposition 19. *Assuming a common intra-industry incentive, λ_{INTRA} , quantities and emissions relative to the alternative model where firms have a short-term common owner objective are lower for the long-term common owner for all time discount factors $0 < \delta \leq 1$ inter-industry incentives $\lambda_{INTER} > 0$.*

Proposition 20. *Assuming a common time discount factor, δ , mitigation relative to the alternative mitigation-adaptation model where firms have a long-term profit objective are:*

- i. *Higher for the long-term common owner for all intra-industry incentives $0 < \lambda_{INTRA} < 1$ and inter-industry incentives $\lambda_{INTER} > 0$; and*
- ii. *Higher for the SRI for all SRI discount factors $0 < \beta \leq 1$.*
- iii. *Higher for the stakeholder-oriented shareholder for all stakeholder discount factors $0 < \theta \leq 1$.*

Proposition 21. *Assuming a common time discount factor, δ , all active owners that invest in adaptation invest identical amounts.*

Propositions 10 and 12 arises from the long-term common owner and SRI having the additional incentive related to damage to other agents in the model, and the long-term common owner also having the intra-industry incentive. Proposition 11 arises from the long-term common owner having the additional incentives related to the long-term and to damage to other agents in the model. Proposition 13 arises because adaptation is a private good benefiting only the firm. Thus if the incentive to address long-term damage to the firm is embedded in the objective and δ , the parameter driving the incentive, is identical across objectives, then all active owner types with the incentive to address long-term damage to the firm will invest identical amounts in adaptation.

A.4.2 Corporate governance process

Suppose there are two shareholders, $m = 1, 2$, of some firm, say firm i , and firm i 's choices and outcomes are determined by management combining the recommendations of shareholders. Further suppose each shareholder's control over management and thus also the firm's final choice or outcome is represented by a control weight, $w_{i,m}$, where $\sum_m w_{i,m} = 1$, and shareholders provide their recommendations truthfully (so do not strategically choose what they recommend to management) and in accordance with a model where they are in full control. The firm's choices, c_i , and outcomes, o_i , are therefore given by:

$$c_i = \sum_m w_{i,m} c_{i,m} = c_{i,m} + w_{i,-m} (c_{i,-m} - c_{i,m}), \quad (\text{A.179})$$

$$o_i = \sum_m w_{i,m} o_{i,m} = o_{i,m} + w_{i,-m} (o_{i,-m} - o_{i,m}), \quad (\text{A.180})$$

where $c_{i,m}$ and $o_{i,m}$ are the choices and outcomes recommended by shareholder m . Therefore, the impact of increasing the control, as represented by the control weights, of shareholder $-m$ is:

$$\frac{\partial c_i}{\partial w_{i,-m}} = c_{i,-m} - c_{i,m}, \quad (\text{A.181})$$

$$\frac{\partial o_i}{\partial w_{i,-m}} = o_{i,-m} - o_{i,m}. \quad (\text{A.182})$$

Thus, if shareholder m is taken to be the short-term profit maximizer and shareholder $-m$ is taken to be an owner with any other active ownership objective, then the impact on firm-level choices and outcomes of increasing the control weight of the owner with the other active ownership objective is the difference between those choices and outcomes recommended by the owner with the other active ownership objective and those choices and outcomes recommended by the short-term profit maximizer.

Appendix B

Appendices for Chapter 3

B.1 Robustness tests for Section 3.3.2 and Section 3.3.3

In this section, I present the results of robustness tests for statements made in Sections 3.3.2 and 3.3.3. These robustness tests rely on the replication package provided by Ashraf, Field, and Lee (2019). These robustness tests confirm that, under the assumptions I derive from AFL, the interpretations I reach through use of the power-based framework developed in this paper are robust; that is, application of the framework developed in Section 3.2 given AFL's assumptions indicates that only a minority of wives were disempowered by treatment, while a majority were (weakly) empowered by (Couple) treatment. However, under alternative assumptions, some of which drive the robustness tests, the conclusions are more complex. Specifically, these robustness tests appear to indicate that at least 23% of households were households in which wives were disempowered by (Couple vs Individual) treatment (i.e., the households identified as Responders by AFL), whilst at least 21% of households were households in which the "dominant effect" was to empower wives (this 21% is a group which I identify as Nonresponders in the robustness tests below). By "dominant effect", I mean there is evidence to suggest that some wives in the 21% of households were disempowered by treatment, however, the overall effect indicates wives in this 21% were empowered "as a whole." Furthermore, conditional on voucher use, wives in the 23% were, as expected given the results above under alternative assumptions to AFL, disempowered by treatment with respect to receiving the injectable. However, in contrast to the above results under alternative assumptions to AFL, the dominant effect of treatment on the power of wives in the 21% with respect to receiving the injectable conditional on voucher use was disempowerment. Furthermore, I present results indicating that the nurse or clinic may also have played an important role in the prescription of injectables, conditional on voucher use, among these groups. For the remaining 61%, among whom, on average, approximately 5% have a missing responder indicator, I present evidence consistent with households being drawn from the above two groups and a third group consisting of

households in which there is no conflict of preferences.

The robustness tests relate to four potential issues with AFL's analysis, and a fifth potential issue with the application of Proposition 16 to (the robustness test) results. There is also an important limitation, which I do not resolve. First, as discussed in footnote 44, it appears that, in order to "capture as many conflicts as possible", it may have been more appropriate to use an 'or', not 'and', in the classification approach for Responders. This is because, by using an 'and', the amount of conflicts captured must be weakly less than those if 'and' were not used, and, by using an 'or', weakly more conflicts must be captured. Second, as noted in footnote 45, using strict inequalities for classification in the Responder group implies weak inequalities in the Nonresponder group, which, assuming AFL's classification approach is correct, would shrink the average treatment effect estimates for the Nonresponders towards zero relative to the average treatment effect estimates for Responders. This is because households for which there is no conflict of preferences are classified as Nonresponders. Third, as discussed in Section 3.3.3, footnote 45 and footnote 53, the effect of treatment on power alone, β_A , is likely overestimated due to treatment affecting both power and preferences. Fourth, as mentioned in footnote 45, the qualitative statements made with respect to the study are directional and, therefore, statistical significance should be assessed using one-sided hypothesis tests. Fifth, in Proposition 16 it is assumed that the effect on power is uniform for all agents (i.e., assumption iii.). However, this need not be the case; either sign of β_A can be generated without a uniform effect on power depending on the distribution of variables, and the magnitude and signs of effects on power. Finally, the classification scheme for Responders and Nonresponders relies on characteristics at baseline, whilst the treatment effect is assessed after wives received the voucher. To the best of my knowledge, there is no information with which I can resolve this issue, so I simply assume that the characteristics at baseline not only reflect preferences for contraception at baseline, but also reflect the preferences of wives after receiving the voucher, which is a limitation of my analysis.

Given the first two potential issues relate to classification, are consequential for assessing the third and fourth potential issues and provide an example of the fifth potential issue relevant to drawing accurate conclusions from AFL's experiment, I begin by discussing the robustness tests for the first two potential issues, where the effect of each adjustment on the overall size of the Responders can be seen in Table B.1.¹ To investigate the robustness of these results to the potential issues with classification identified above, I generate results using the AFL dataset under the various classification alternatives suggested. The results can be seen in Table B.2 below. As expected, replacing the 'and' with the 'or' reduces the estimates of the average treatment effects in both samples, particularly in the Nonresponder sample. For Nonresponders the average treatment effect is still negative and insignificant for voucher use. However,

¹In Table B.1, note that the percentage of the sample with missing Responder indicators varies by sample. I have not addressed this variation and, therefore, it is a limitation of this additional analysis.

	Responders (% of sample)
AFL's classification	23
'Or' instead of 'and'	44
Equalities in inequalities	64
'Or' instead of 'and', and equalities in inequalities	69

Table B.1: Percentage of sample in Responders. Note that, on average, approximately 5% of the sample have a missing Responder indicator across all approaches to classification as Responders. The exact percentages vary by sample.

	Responders		Non-Responder	
	Voucher Redeemed	Received Injectable	Voucher Redeemed	Received Injectable
AFL's classification	-0.159** (0.076)	-0.136** (0.064)	-0.070 (0.043)	-0.029 (0.035)
'Or' instead of 'and'	-0.133** (0.056)	-0.089** (0.044)	-0.024 (0.055)	0.009 (0.045)
Equalities in inequalities	-0.112** (0.045)	-0.089** (0.038)	-0.074 (0.062)	0.011 (0.050)
'Or' instead of 'and', and equalities in inequalities	-0.104** (0.044)	-0.088** (0.036)	-0.062 (0.070)	0.024 (0.056)

Table B.2: Average treatment effect estimates using different Responder classifications relative to the classification used by AFL. 'Or' instead of 'and' corresponds to a Responder classification in which households are classified as Responders if the wife does not want to have a child in the next two years, in which the wife believes the husband's ideal number of children is larger than the households current number of children or in which the wives believe the husband wants more children than the household currently has, and or in which the wife believes the husband has a higher maximum, ideal or minimum number of desired children than she does. Equalities instead of inequalities shifts the statements, other than the desirability of children in the next two years, from statements corresponding to strict to weak inequalities. For example, 'larger than' becomes 'larger than *or equal to*.' Statistical significance is assessed using the usual two-sided test and indicated as follows: *** significant at the 1% level, ** significant at the 5% level, *significant at the 10% level.

the average treatment effect for receiving injectables becomes positive whilst still being statistically insignificant. When equalities instead of inequalities are used in the classification for Responders, the average treatment effect in Responders decreases by approximately 30% for voucher use and approximately 35% for receiving injectables, in line with expectations. However, for Nonresponders, the average treatment effect for voucher use, but not receiving injectables, remains virtually unchanged despite a 61% reduction in the number of the Nonresponders (see Table B.1). Whilst this may appear to imply that the conjecture that replacing strict inequalities with weak inequalities would identify the households in which there are no conflicts of preferences, if however viewed in combination with the changes observed when both changes to the classification approach are applied, it may instead serve as further evidence that using 'and' instead of 'or' was initially less correct. This is for two reasons. First, the changes in average treatment effects from introducing equality signs into the Responder condition was based on the assumption that 'and' was correct to begin with. Thus, receiving unexpected results may serve as further evidence against the assumption. Second, as can be seen in Table B.2, the average treatment effects all exhibit non-negligible changes when the strict inequalities are replaced with weak inequalities after replacing 'and' with 'or'. Finally, I note a result from addressing these two potential issues that has important implications for drawing later conclusions; when (approximately) shifting the households for which there are no conflicts in preferences by moving the equality signs after changing 'and' to 'or', for Nonresponders the average treatment effect on voucher use decreases whilst the average treatment effect on receiving the injectable *increases*. This appears to imply that the effect on power for Nonresponders is not uniform, at least across the difference outcomes, potentially rendering Proposition 16 inapplicable. Results addressing this issue, which also provide further supporting evidence that the adjustments to classification scheme are accurate, will be provided further below. However, before doing so, I next investigate the effects of addressing the third and fourth potential issues identified above.

Since addressing the fourth issue requires little further explanation (i.e., adjusting to a one-sided hypothesis test is relatively straightforward), I focus here on addressing the third issue. To do so, I use results from Ashraf, Field, and Leight (2013), who implement a similar treatment to AFL in an almost identical sample, however, the household receives a voucher or does not (handed to the wife in the presence of the husband if treated), rather than the wife receiving the voucher in secret or not. In Table 2 of their paper, Ashraf, Field, and Leight (2013) provide two estimates of the average treatment effect on reported usage of injectables over the past two years (thus, the outcome variable does not exactly match the outcome in AFL, which is usage of injectables due to redemption of the voucher) corresponding to different subsamples; 0.073 and 0.105. Now, if it is assumed that the husband has complete control of the household decision, as AFL appear to imply ("[t]he Couple treatment, by essentially giving husbands veto power over contraceptives provided throughout the study, approximates the spousal consent

rules governing many family planning services offered through public and private clinics in much of the developing world") since veto power over a binary decision implies the ability to determine that decision, then the average treatment effects in Ashraf, Field, and Leight (2013) can be taken as approximations of the average treatment effects of the voucher on husbands' preferences for receiving the injectable, $\mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)]$.² Furthermore, since the voucher must be redeemed in order to receive the injectable, but one does not necessarily receive the injectable by using the voucher, then the effects from Ashraf, Field, and Leight (2013) can be considered lower bounds on the effect on voucher use.³

In Tables B.3 and B.4 below, I provide results with the average treatment effect estimates adjusted by either 0.073 and 0.105, and from using one-sided instead of two-sided hypothesis tests.⁴ As can be seen, the results for Nonresponders mostly become statistically significant, particularly for voucher use. In both tables, I adjust the average treatment effects for Responders by 0.073 only, whilst, for Nonresponders, in Table B.3 the average treatment effects are adjusted by 0.105 and in Table B.4 the average treatment effects are adjusted by 0.073. The reason for the asymmetry is that it seems reasonable to assume that the effect of the voucher on receiving injectables would be larger for Nonresponders. This is because husbands in Nonresponder households are more inclined to want their wives to be on contraception relative to husbands in households classified as Responders, that is, it seems reasonable that $\mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)|\text{Nonresponder}] \geq \mathbb{E}[Y_{i,B}(1) - Y_{i,B}(0)|\text{Responder}]$. Furthermore, conclusions for Responders would be largely unaffected by using a larger adjustment.

It is, however, the case that some results for Nonresponders in Table B.4, whilst still negative and therefore indicating at least some degree of empowerment among wives in these households, are not statistically significant. Given i) this negative but statistically insignificant result is consistent with the indication above that some wives were disempowered by treatment with respect to receiving injectables, and ii) that there appears to be a clear negative effect of treatment with respect to voucher use for Nonresponders, I now present evidence that some wives in the Nonresponder households indeed were, conditional on using the voucher, disempowered by treatment with respect to receiving injectables. Furthermore, this evidence also appears to suggest, but not necessarily causally, that nurses or the clinic played an important role in households receiving injectables and that this role depended largely on the relative preferences between the wife and husband.

²This result also follows using the weaker assumptions in Lemma 3. Assuming wives have relatively low power, it is also approximately true for Nonresponders based on similar points to those in footnote 52 of Section 3.3.3.

³Since the outcome variable in Ashraf, Field, and Leight (2013) potentially includes receiving the injectable via means other than using the voucher, the effect measured in Ashraf, Field, and Leight (2013) may be considered an overestimate. However, given the difficulty of receiving injectables outlined in Ashraf, Field, and Leight (2013) and AFL, and the ease with which they could be sourced with the voucher, I assume the impact of such effects are negligible.

⁴Results from other combinations of these adjustments can be seen in Tables B.6 and B.7 in Appendix B.2.

	Responders		Non-Responder	
	Voucher Redeemed	Received Injectable	Voucher Redeemed	Received Injectable
AFL's classification	-0.232*** (0.076)	-0.209*** (0.064)	-0.175*** (0.043)	-0.134*** (0.035)
'Or' instead of 'and'	-0.206*** (0.056)	-0.162*** (0.044)	-0.129*** (0.055)	-0.096** (0.045)
Equalities in inequalities	-0.185*** (0.045)	-0.162*** (0.038)	-0.179*** (0.062)	-0.094** (0.050)
'Or' instead of 'and', and equalities in inequalities	-0.177*** (0.044)	-0.161*** (0.036)	-0.167*** (0.070)	-0.081* (0.056)

Table B.3: Adjusted average treatment effect estimates using different Responder classifications relative to the classification used by AFL. For the Responders, average treatment effects from Table B.2 are reduced by 0.073. For the Nonresponders, average treatment effects from Table B.2 are reduced by 0.105. Standard errors are identical to Table B.2. 'Or' instead of 'and' corresponds to a Responder classification in which households are classified as Responders if the wife does not want to have a child in the next two years, in which the wife believes the husband's ideal number of children is larger than the households current number of children or in which the wives believe the husband wants more children than the household currently has, and or in which the wife believes the husband has a higher maximum, ideal or minimum number of desired children than she does. Equalities instead of inequalities shifts the statements, other than the desirability of children in the next two years, from statements corresponding to strict to weak inequalities. For example, 'larger than' becomes 'larger than or equal to.' Statistical significance is assessed using a one-sided test, where the null hypothesis is an effect greater than or equal to zero. Statistical significance is indicated as follows: *** significant at the 1% level, ** significant at the 5% level, *significant at the 10% level.

	Responders		Non-Responder	
	Voucher Redeemed	Received Injectable	Voucher Redeemed	Received Injectable
AFL's classification	-0.232*** (0.076)	-0.209*** (0.064)	-0.143*** (0.043)	-0.102*** (0.035)
'Or' instead of 'and'	-0.206*** (0.056)	-0.162*** (0.044)	-0.097** (0.055)	-0.064* (0.045)
Equalities in inequalities	-0.185*** (0.045)	-0.162*** (0.038)	-0.147*** (0.062)	-0.062 (0.050)
'Or' instead of 'and', and equalities in inequalities	-0.177*** (0.044)	-0.161*** (0.036)	-0.135** (0.070)	-0.049 (0.056)

Table B.4: Adjusted average treatment effect estimates using different Responder classifications relative to the classification used by AFL. For both Responders and Nonresponders, average treatment effects from Table B.2 are reduced by 0.073. Standard errors are identical to Table B.2. 'Or' instead of 'and' corresponds to a Responder classification in which households are classified as Responders if the wife does not want to have a child in the next two years, in which the wife believes the husband's ideal number of children is larger than the households current number of children or in which the wives believe the husband wants more children than the household currently has, and or in which the wife believes the husband has a higher maximum, ideal or minimum number of desired children than she does. Equalities instead of inequalities shifts the statements, other than the desirability of children in the next two years, from statements corresponding to strict to weak inequalities. For example, 'larger than' becomes 'larger than *or equal to*.' Statistical significance is assessed using a one-sided test, where the null hypothesis is an effect greater than or equal to zero. Statistical significance is indicated as follows: *** significant at the 1% level, ** significant at the 5% level, *significant at the 10% level.

To do so, I add voucher use, responder classification and various interaction terms into a single econometric specification for receiving injectables. The results of this analysis can be seen in Table B.5, from which the following two results are important. First, given the voucher is used, the effect of treatment is positive and economically significant, but not statistically significant for Nonresponders. This indicates that some wives in the Nonresponder sample were disempowered with respect to receiving the injectable (i.e., they received it when they did not want to). Furthermore, this effect does not change signs using the adjustments above sourced from Ashraf, Field, and Leight (2013).⁵ Second, it appears the nurse or clinic may have played an important role for the following reasons, and that an important aspect of this role appears to be have been to resist the preferences of the husband in favor of the wife. First, the treatment effect is zero. This confirms the intuition that the effect of receiving injectables is only through redeeming the voucher with the nurse at the clinic, and does not have a direct effect. Second, the effect of voucher use on receiving injectables is positive, economically large, and highly statically significant. Furthermore, it is, arguably, difficult to explain as entirely due to baseline demand for contraception or the effect of preference treatment sourced from Ashraf, Field, and Leight (2013) on the households preference for receiving injectables.⁶ Finally, there is a negative, economically large and statistically significant difference between the effects of treatment conditional on voucher use and responder classification, which also implies that among Nonresponders treatment had an economically significant, positive effect on the effect of using the voucher whilst among Responders treatment had an economically significant, negative effect on the effect of using the voucher (each of these effects are, however, statistically insignificant on their own). Given this statistically significant difference across samples, the difference in signs of effects across samples and the relative preferences across samples, it appears the nurses or clinic were been able to significantly, but not entirely, resist the preferences of the husband (from the perspective of the husband having veto power or general decision-making rights in the household). Interestingly, this resistance appears to have been stronger for Nonresponders. To see how, first suppose the household is a Responder, where the husband prefers no injectables and the wife prefers injectables. If the husband were to always get his way, then the probability of receiving injectables given treatment (where the husband has full information about the voucher), voucher use and being a responder should be 0 but it is 0.384.

⁵Also note that the effect of treatment conditional on voucher use remains negative under AFL's Responder classification scheme, implying that the interpretation I suggest under AFL's assumptions is robust to this analysis (even if only marginally given the very small coefficient).

⁶Using the statistics in Table 1 of AFL, the rate of injectable usage conditional on using a contraception method at baseline (which may be taken as an indication of demand for contraception in the household, which may then be captured in voucher usage), is approximately 24%. Given this initial approximation, approximately 16% to 22% remains unexplained in the effects observed in Table B.5. It may be suggested that some of this remaining unexplained effect is attributable to the preference effect of the voucher on receiving the injectable, which may be approximated using the results from Ashraf, Field, and Leight (2013) as either 7.3% or 10.5%. Whilst attributing this effect to voucher use still leaves approximately 6% to 15% unexplained, this effect is perhaps more appropriately attributed to the effect of treatment conditional on voucher use (i.e., the interaction term between treatment and voucher use) since the treatment variable carries the effect of the preference treatment.

	AFL's classification	'Or' instead of 'and'	'Or' instead of 'and', and equalities in inequalities
Treatment	0.000 (0.040)	0.000 (0.052)	0.000 (0.064)
Voucher use	0.459*** (0.042)	0.444*** (0.053)	0.400*** (0.070)
Responder	0.000 (0.066)	0.000 (0.055)	0.000 (0.056)
Treatment x Voucher use	-0.001 (0.059)	0.042 (0.076)	0.125 (0.099)
Treatment x Responder	0.000 (0.090)	0.000 (0.076)	0.000 (0.077)
Voucher use x Responder	-0.009 (0.085)	-0.016 (0.076)	0.070 (0.081)
Treatment x Voucher use	-0.126 (0.125)	-0.114 0.109	-0.211* (0.116)
Responder			

Table B.5: Effects of treatment on receiving injectables conditional on voucher use. Statistical significance is assessed using a two-sided test and indicated as follows: *** significant at the 1% level, ** significant at the 5% level, *significant at the 10% level. Intercept terms are close to zero.

For a similar circumstance among Nonresponders, the probability should be 1 and it is 0.525. In both cases, the differences from the husbands' assumed preferences are economically and statistically significant, however, the difference is noticeably larger for Nonresponders than Responders. These results appear to indicate the nurse or clinic played an important, but complex role, in the provision of injectables; despite the nurse or clinic appearing to exhibit a preference for prescribing injectables⁷ and treatment given voucher use generally disempowering wives, it appears the nurse or clinic was able to resist the preferences of husbands in favor of wives to a considerable degree and, perhaps surprisingly, this degree of resistance was larger where the husband preferred injectable use despite the nurse's or clinic's apparent preference for prescribing injectables.

Collectively, these results appear to indicate that there is a group, at least as large as the Responders identified by AFL, for whom treatment was disempowering. Given the observed pattern of results among various classification schemes for Nonresponders, there also appears to be a group, at least as large as the Nonresponders under the 'or' instead of 'and' and equalities in inequalities group, for whom the "dominant effect" of treatment was empowering; this is because the observed effects of treatment are generally negative. However, among this latter group, the effect of treatment conditional on using the voucher was indeed disempowering. Given this set of results, a valid question is what was the effect on the remaining households? Since these households are either drawn from the above two groups, I show that the effect for the remaining households is at least consistent with households being drawn from these two types of households, or a household in which there is no conflict of preferences as also postulated above. If households are drawn from any of these three types of households, then the treatment effect should be negative. This is because the effect is negative for Responders, the dominant effect for Nonresponders is negative, and the effect where there is no conflict should be zero. Indeed, the effect is negative in this remaining group; the effect on voucher use is -0.079 with a standard error of 0.056 and the effect on receiving injectables is -0.067 with a standard error of 0.046. Neither are statistically significant based on a two-sided test, however both are statistically significant at the 10% level based on a one-sided test where the null hypothesis is that the effects are greater than or equal to zero.

⁷This is exhibited by the nurse or clinic prescribing injectables above baseline demand within the sample.

B.2 Additional results for robustness tests in Appendix B.1

	Responders		Non-Responder	
	Voucher	Received	Voucher	Received
	Redeemed	Injectable	Redeemed	Injectable
AFL's classification	-0.232*** (0.076)	-0.209*** (0.064)	-0.143*** (0.043)	-0.102*** (0.035)
'Or' instead of 'and'	-0.206*** (0.056)	-0.162*** (0.044)	-0.097* (0.055)	-0.064 (0.045)
Equalities in inequalities	-0.185*** (0.045)	-0.162*** (0.038)	-0.147** (0.062)	-0.062 (0.050)
'Or' instead of 'and', and equalities in inequalities	-0.177*** (0.044)	-0.161*** (0.036)	-0.135* (0.070)	-0.049 (0.056)

Table B.6: Adjusted average treatment effect estimates using different Responder classifications relative to the classification used by AFL. For both Responders and Nonresponders, average treatment effects from Table B.2 are reduced by 0.073. Standard errors are identical to Table B.2. 'Or' instead of 'and' corresponds to a Responder classification in which households are classified as Responders if the wife does not want to have a child in the next two years, in which the wife believes the husband's ideal number of children is larger than the households current number of children or in which the wives believe the husband wants more children than the household currently has, and or in which the wife believes the husband has a higher maximum, ideal or minimum number of desired children than she does. Equalities instead of inequalities shifts the statements, other than the desirability of children in the next two years, from statements corresponding to strict to weak inequalities. For example, 'larger than' becomes 'larger than *or equal to*.' Statistical significance is assessed using the usual two-sided test and is indicated as follows: *** significant at the 1% level, ** significant at the 5% level, *significant at the 10% level.

	Responders		Non-Responder	
	Voucher	Received	Voucher	Received
	Redeemed	Injectable	Redeemed	Injectable
AFL's classification	-0.159** (0.076)	-0.136** (0.064)	-0.070* (0.043)	-0.029 (0.035)
'Or' instead of 'and'	-0.133*** (0.056)	-0.089** (0.044)	-0.024 (0.055)	0.009 (0.045)
Equalities in inequalities	-0.112*** (0.045)	-0.089*** (0.038)	-0.074 (0.062)	0.011 (0.050)
'Or' instead of 'and', and equalities in inequalities	-0.104*** (0.044)	-0.088*** (0.036)	-0.062 (0.070)	0.024 (0.056)

Table B.7: Average treatment effect estimates using different Responder classifications relative to the classification used by AFL. 'Or' instead of 'and' corresponds to a Responder classification in which households are classified as Responders if the wife does not want to have a child in the next two years, in which the wife believes the husband's ideal number of children is larger than the households current number of children or in which the wives believe the husband wants more children than the household currently has, ~~and~~ or in which the wife believes the husband has a higher maximum, ideal or minimum number of desired children than she does. Equalities instead of inequalities shifts the statements, other than the desirability of children in the next two years, from statements corresponding to strict to weak inequalities. For example, 'larger than' becomes 'larger than *or equal to*.' Statistical significance is assessed using a one-sided test, where the null hypothesis is an effect greater than or equal to zero. Statistical significance is indicated as follows: *** significant at the 1% level, ** significant at the 5% level, *significant at the 10% level.

Appendix C

Appendices for Chapter 4

C.1 Extended taxonomy

In this section, we list and briefly describe maximization problems not included in Section 4.2. Similar to those maximization problems presented in Section 4.2, many of these maximization problems are drawn from various theories of the firm. In some cases, they are elaborations of these theories that we believe to be reasonable. For practical reasons, we do not cover maximization problems for every possible theory; we focus on those that were either very prominent and have been less studied recently, those that have had recent theoretical development, or are important in practice. The maximization problems we cover in this section include financial wealth maximization, long-term, broad, financial wealth common ownership, universal ownership, team production theory, and corporate purpose.

Financial wealth maximization expands beyond profits to include other financial interests in the firm. Under financial wealth maximization ('FW'), the objective function is given by:

$$\varphi_{FW} = \varphi_{LTP} + \sum_t \delta_t \pi_{3,t}$$

where those with financial claims other than shareholders' are assumed to be the stakeholder group for which $j = 3$, $\pi_{3,t}$ represents payoffs to this group in period t , δ_t is the discount factor applied to these payoffs in period t and $\delta_1 = 1$.

For financial wealth maximization, the only constraints we suggest are participation constraints and production technology constraints. Thus, the maximization problem for financial wealth maximization is given by:

$$\begin{aligned}
& \max_{a_i} \quad \varphi_{FW} \\
& \text{s.t.} \quad \tilde{\pi}_1 \geq w_1, \\
& \quad \tilde{\pi}_j \geq w_j \mathbb{1}\{a_i \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a_i \in A_{j,cp}\}) \text{ for all } j \neq 1, \\
& \quad a_i \in A_t(F) \text{ for all } i.
\end{aligned}$$

Financial wealth maximization is intended to represent shareholder wealth maximization,¹ which was a common objective function proposed in the economics and finance literature on firm objectives throughout the 20th century DeAngelo (for an older, but also very useful commentary on this literature, see 1981). It is also an objective function which forms the basis of much of the theory of financial economics (Schmalz, 2018). In this literature, which was largely positive rather than normative, it was generally concluded that firms would maximize the financial wealth of owners, where the owners of firms were almost always considered to be shareholders. To the best of our knowledge, the most recent normative argument for financial wealth maximization was put forward by Jensen (2001a) and Jensen (2001b, 2002), who suggests that, under some assumptions, firms acting according to financial wealth maximization "makes society better off" by maximizing welfare.

In the maximization problem for financial wealth maximization, we do not include legal and ethical constraints. This is because the connection to these constraints in the literature on financial wealth maximization seemed relatively weak, which we pursued by following citations on Jensen (2001a) and Jensen (2001b, 2002) and through other references. For example, Jensen (2001a) is cited by Wallace (2003). Wallace (2003) then cites Hayek (2022), who is very clear about conforming to "legal and moral rules." However, both Jensen (2001a) and Jensen (2001b, 2002) and Wallace (2003) do not discuss this conformism, and, upon further reading, Hayek (2022) seems to mix references to profit maximization and financial wealth maximization. Furthermore, Zingales (2000), a highly cited finance paper on the theory of the firm,² whilst mentioning the law governing corporations, does not seem to emphasize moral constraints on firm behavior.³ Finally, in his commentary on the positive theories mentioned in the previous paragraph, DeAngelo (1981) does not specifically mention legal and ethical con-

¹We use the term financial wealth maximization rather than shareholder wealth maximization for clarity and to clearly delineate financial wealth maximization from profit maximization. We note also that the objective function of financial wealth maximization is also sometimes referred to as 'firm value', particularly in the finance literature. For clarity, we also do not use label this maximization problem firm value maximization as, arguably, the value created by a firm includes more than the value the firm creates for financial claimants.

²Note, however, that Zingales (2000) does not appear to address firm objective functions and maximization problems, although Zingales (2000) does address the "value of the firm", governance and how surplus is allocated "among its members".

³We acknowledge this is in stark contrast to more recent work by Professor Zingales. See, for example, Hart and Zingales (2017), Zingales (2017), Broccardo, Hart, and Zingales (2022)

straints.⁴

The next maximization problem we present is long-term, broad, financial wealth common ownership ('LTBFWCO'). This form of common ownership is similar to long-term, broad common ownership, except financial wealth, not only profits, appears in a firm's objective function. Therefore, the objective function and maximization problem are given by:

$$\varphi_{LTBFWCO} = \varphi_{FW} + \sum_{j \in INTRA} \lambda_j \varphi_{FW,j} + \sum_{k \in VINTER} \lambda_k \varphi_{FW,k} + \sum_{l \in HINTER} \lambda_l \varphi_{FW,l}$$

$$\begin{aligned} \max_{a_i} \quad & \varphi_{LTBFWCO} \\ \text{s.t.} \quad & \tilde{\pi}_1 \geq w_1, \\ & \tilde{\pi}_j \geq w_j \mathbb{1}\{a_i \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a_i \in A_{j,cp}\}) \text{ for all } j \neq 1, \\ & a_i \in A_t(F) \text{ for all } i. \end{aligned}$$

The primary reason for including this maximization problem is that it represents the portfolio interests of institutional investors more accurately than the forms of common ownership presented in Section 4.2. In Section 4.2, we argued for the appropriateness of the maximization problem for long-term, broad common ownership on the basis of its objective function accurately representing the equity portfolio of institutional investors. However, an institutional investor's investment portfolio may include other financial claims on firms, such as a firm's debts. Therefore, for the same legal and economic reasons given in Section 4.2, the objective function pursued by institutional investors may be to maximize their assets under management, or financial wealth, which, under the usual assumptions used to aggregate investors' objective functions in the common ownership literature, may lead to firms solving the maximization problem presented for long-term, broad, financial wealth common ownership.

A notion related to, but somewhat different from, common ownership is universal ownership. We propose two types of universal ownership; macro universal ownership and micro universal ownership. For macro universal ownership ('Macro-UO'), we adopt the objective function for socially responsible investors where, however, instead of considering the interests of 'society', the macro universal owner considers the interests of the 'economy'. That is, $\varphi_{Macro-UO} = \varphi_{SRI}$, however, the group for which $j = 2$ is the 'economy' rather than 'society'. For micro universal ownership ('Micro-UO'), we adopt the objective function of long-term, broad financial wealth common ownership. That is, $\varphi_{Micro-UO} = \varphi_{LTBFWCO}$. In addition to participation constraints, we include constraints for both types of universal ownership, denoted A_{uo} . The maximization problem for each type of universal ownership is therefore given

⁴DeAngelo (1981) does restrict firm decisions to a feasible set. However, what determines feasibility does not appear to be specified. The example given by DeAngelo (1981) is "firms' possibilities set", which we believe to be referring to the production possibility set of a firm.

by:

$$\begin{aligned}
& \max_{a_i} \varphi_{Macro-UO} \\
& \text{s.t. } \tilde{\pi}_1 \geq w_1, \\
& \quad \tilde{\pi}_j \geq w_j \mathbb{1}\{a_i \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a_i \in A_{j,cp}\}) \text{ for all } j \neq 1, \\
& \quad a_i \in A_t(F) \text{ for all } i. \\
& \quad a_i \in A_{uo} \text{ for all } i, \\
\\
& \max_{a_i} \varphi_{Micro-UO} \\
& \text{s.t. } \tilde{\pi}_1 \geq w_1, \\
& \quad \tilde{\pi}_j \geq w_j \mathbb{1}\{a_i \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a_i \in A_{j,cp}\}) \text{ for all } j \neq 1, \\
& \quad a_i \in A_t(F) \text{ for all } i. \\
& \quad a_i \in A_{uo} \text{ for all } i,
\end{aligned}$$

We justify these maximization problems for universal ownership as follows. First, we believe macro universal ownership accurately represents the objective function of universal ownership as initially outlined by Monks (1996) and further developed by Hawley and Williams (2000a) and Hawley and Williams (2000b). This is because these papers primarily focus on institutional investors as ‘owners’ only and, arguably, from a quasi-policy perspective. The focus of Monks (1996) and Hawley and Williams (2000a) and Hawley and Williams (2000b) on institutional investors’ role as ‘owners’ only is captured by only including profits, and not cash flows from any other financial claims of institutional investors’, in the objective function. The focus from a quasi-policy perspective is captured by giving weight to the interests of the ‘economy’. This quasi-policy perspective may be seen in Monks (1996) and Hawley and Williams (2000a) and Hawley and Williams (2000b). For example, it is suggested by Monks (1996) that “[t]heir holdings are so diversified that they have the incentive to represent the ownership sector (and the economy) generally rather than any specific industries or companies. This endows them with a breadth of concern that naturally aligns with the public interest.” Furthermore, Hawley and Williams (2000a) suggest that “a universal owner ... cares not only about the governance and performance of the individual companies that compose its investment portfolio, but ... also cares about the performance of the economy as a whole.” Finally, taking a quasi-policy-level perspective by focusing on the “economy as a whole”, rather than micro-level interactions between firms, is further exemplified by the policy-like approaches to universal ownership suggested by Hawley and Williams (2000b).

Second, we believe that micro universal ownership is an accurate representation of more recent developments in universal ownership theory. Recent developments in universal ownership theory have tended to focus on the actual portfolio of institutional investors, including all of the financial interests of universal owners, and has tended to shy away from claims

of suggesting universal owners have an interest in the "economy as a whole" (Hawley and Williams, 2000a). For example, the "[f]ormal description of universal owner theory" presented by Gosling (2024) clearly focuses on portfolio-level returns to the institutional investor; "[a]sset owners should use their influence to reduce market-wide risks where they can, even if in so doing they reduce long-term returns of particular companies or sectors within their portfolio, provided this reduction, plus the cost of taking action, is outweighed by the positive long-term return or risk-reduction impact on the remainder of the portfolio." Contrary to the objective function for macro universal ownership, this definition also addresses criticisms that universal owners do not in fact 'own the economy' (see, for example, Condon, 2020; Kahan and Rock, 2022; Tallarita, 2023) and is in line with a recent shift in describing universal owners as 'asset owners', where, to avoid confusion, 'asset owners' refers to the ownership of financial assets by institutional investors rather than the assets of firms (see, for example, Gosling, 2024; Quigley, 2020).

Finally, we include the constraints outlined in each maximization problem for the following reasons. First, if micro universal ownership is to differ from long-term, broad, financial wealth common ownership, then the universal owner constraints, $a_i \in A_{uo}$, must be restrictive in some sense. To the best of our knowledge, these constraints are yet to be clearly articulated, however, given the recent concern about the anti-competitive effects of common ownership, it seems reasonable that universal ownership constraints should at least restrict firms from taking actions that are anti-competitive. Second, legal constraints are omitted since encouraging firms to follow the law does not appear to be emphasized in universal ownership theory. Rather, much of the focus appears to be on influencing the law through policy advocacy (see, for example, Gosling, 2024; Hawley and Williams, 2000b).

We next address team production theory (Blair and Stout, 1999). For team production theory ('TP'), we suggest the narrow stakeholder maximization problem from Section 4.2 but without purpose constraints. Specifically, $\varphi_{TP} = \varphi_{S_N}$. Then, the maximization problem for team production theory may be given by:

$$\begin{aligned} \max_{a_i} \quad & \varphi_{TP} \\ \text{s.t.} \quad & \tilde{\pi}_j \geq w_j \text{ for all } j \in S_N, \\ & \tilde{\pi}_j \geq w_j \mathbb{1}\{a_i \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a_i \in A_{j,cp}\}) \text{ for all } j \notin S_N, \\ & a_i \in A_t(F) \text{ for all } i. \\ & a_i \in A_i \text{ for all } i, \end{aligned}$$

We believe this is an adequate representation for the following reasons. Team production theory suggests that directors of public corporations mediate between the individuals or groups necessary for production in order to ensure their participation and are responsible for the di-

vision of surplus among these individuals and groups. Whilst directors may consider any group that contributes to the success of the corporation (Stout, 2017), those included in the narrow stakeholder group may be an adequate approximation. Thus, the objective function and participation constraints from narrow stakeholder maximization likely apply to team production theory. Furthermore, legal constraints likely apply; whilst Blair and Stout (1999) suggest that decisions "within" the corporation ultimately lie with directors, they also suggest that this claim should not be "read too broadly" as courts will intervene in some circumstances.⁵ Finally, the purpose constraints likely do not apply since (Stout, 2017) proposes team production theory as a corporate purpose.

Finally, we address corporate purpose (see, for example, Mayer, 2021). For corporate purpose, we suggest two maximization problems; constraint-based purpose maximization ('CP') and objective-based purpose maximization ('OP'). Constraint-based purpose maximization is equivalent to the wide stakeholder maximization problem, where $\varphi_{CP} = \varphi_{SB}$. For objective-based purpose maximization, we suggest the same constraints as the wide stakeholder maximization problem and, for the reasons given further below, simply denote the objective function as φ_{OP} where φ_{OP} is a non-binary measure of performance that reflects how well a firm achieves its corporate purpose. Since the maximization problem for constraint-based purpose maximization is equivalent to the wide stakeholder maximization problem, we only state the maximization problem for objective-based purpose maximization, which is given by:

$$\begin{aligned}
 & \max_{a_i} \quad \varphi_{OP} \\
 & \text{s.t.} \quad \tilde{\pi}_j \geq w_j \quad \text{for all } j \in S_W, \\
 & \quad \tilde{\pi}_j \geq w_j \mathbb{1}\{a_i \in A_{j,cp}\} - \infty \times (1 - \mathbb{1}\{a_i \in A_{j,cp}\}) \quad \text{for all } j \notin S_W, \\
 & \quad a_i \in A_t(F) \quad \text{for all } i. \\
 & \quad a_i \in A_l \quad \text{for all } i, \\
 & \quad a_i \in A_p \quad \text{for all } i.
 \end{aligned}$$

We believe these maximization problems may be appropriate for corporate purpose for the following reasons. First, including the participation, legal and purpose constraints may address the requirement that firms are "not profiting from producing problems" Mayer (2021) since these constraints may exclude actions by firms that negatively impact others. Second, the two maximization problems allow two different interpretations of corporate purpose. First, purpose may be seen as binary as in constraint-based purpose maximization; the firm either

⁵Blair and Stout (1999) also suggest that corporations have a "fundamentally political nature" and that the groups within corporations "will inevitably use political tools, in addition to economic and legal tools, to try to capture a larger share of the rents produced by team production." Such a statement may somewhat undercut the application of legal constraints since following legal constraints is then subject to politics. Nonetheless, those individuals or groups with sufficient power may impose legal constraints on the firm.

achieves its purpose or does not. Examples of binary purposes can be seen in the examples given for Novo Nordisks corporate purpose by Mayer (2021). Over time, Novo Nordisk's purpose evolved from being "to produce insulin", to "to help people treat Type 2 diabetes", then finally to "to help people avoid getting diabetes." Each of these purposes can be seen as binary; Novo Nordisk either did them or did not.⁶ Second, a firm may be interested not only in achieving its purpose but also in how well it achieves its purpose. This is captured by objective-based purpose maximization since φ_{OP} is a measure of the firm's performance according to its corporate purpose. This also reflects the proposal that corporate law "make purpose the firm's objective" (Mayer, 2021).

C.2 Objective functions and product market competition

Here, we consider the possible co-existence of firms with different objectives. One might expect that free entry of profit-maximizing firms drives others with non-profit objectives out of the market.⁷ We find that is not necessarily the case. For a meaningful distinction between profit and non-profit objectives, we consider an environment with externalities. In particular, we consider an environment where production generates negative externalities that do not affect profits or profit-maximizers' choices. However, disutility arising from such negative externalities are often taken into consideration by firms with non-profit objectives. Irrespective of the maximands, we assume that all firms have to be viable—i.e., satisfy a non-negative profit constraint. We demonstrate that, indeed, in an environment with free entry of profit-maximizing firms, there is always a Nash equilibrium where only profit-maximizing firms produce a strictly positive amount of output. However, that is not necessarily the only Nash equilibrium. We present an illustrative example that shows the existence of a Nash equilibrium where a firm maximizing welfare co-exists with profit maximizers despite the free entry of the latter group.⁸

Consider a Cournot oligopoly with N (potential) profit-maximizing firms that can produce a homogeneous good. We assume that N is sufficiently large but finite. In addition, there is a firm 0 which maximizes a different objective function which we specify later. The inverse demand for the homogeneous good is given by:

$$P = z - Q$$

⁶Of course, this leaves open the question of the distribution of surplus, which will be determined by φ_{CP} . Since this distribution may occur in many forms (Mayer, 2021), we simply adopt the wide stakeholder objective function as it seems most aligned with looking after "people and planet."

⁷See for example 'Profit Selection Theorem' of Fleurbaey and Ponthière (2023) [emphasis added] for an argument along this line.

⁸Naturally, whether such an equilibrium with non-profit maximizers exists or not depends on the specification of the objective function and the extent of externalities.

where $z > 0$, and P and Q denote price and aggregate output respectively. All firms have identical costs. Cost of producing q units is:

$$C(q) = \frac{q^2}{2} + k$$

where $q > 0$ and 0 otherwise. Producing q units of output emits pollution creates disutility eq to consumers where $e > 0$. Profit-maximizing firms do not take that into account.

First, we characterize the Nash equilibrium where only profit-maximizing firms produce a strictly positive amount of output. Let q_i denote the output produced by firm i ($i = 0, 1, 2, \dots, N$). For the time being, we assume $q_0 = 0$. Each profit-maximizing firm i chooses q_i to maximize its profits:

$$\pi_i \equiv (z - (q_i + \sum_{j \neq i, 0} q_j))q_i - \frac{q_i^2}{2} - k$$

subject to the constraint $\pi_i \geq 0$. Solving the first-order conditions for profit-maximization, i.e.

$$\frac{\partial \pi_i}{\partial q_i} = z - 2q_i - \sum_{j \neq i} q_j - q_i \leq 0, = 0 \text{ if } q_i > 0$$

we find that, in an equilibrium where $n \leq N$ firms are active (i.e., produce strictly positive amount), each active firm produces

$$q_i = \frac{z}{n+2} = q(n)$$

In a free-entry equilibrium, n^* firms are active where $n = n^*$ is the largest positive integer that satisfies

$$P(nq(n))q(n) - C(q(n)) \geq 0$$

Ignoring the integer constraint and assuming that z and K are suitably large we find

$$n^* = \sqrt{\frac{3z^2}{2K}} - 2, \text{ and } q^* = \sqrt{\frac{2K}{3}}$$

Check that

$$P^* = \sqrt{\frac{8K}{3}}, \quad Q^* = z - \sqrt{\frac{8K}{3}}$$

For a concrete example, consider $z = 72$, $K = 54$. Then

$$q^* = 6, \quad n^* = 10$$

If there are $N(> 10)$ profit-maximizing firms with production capability, any 10 firms producing 6 units each and the remaining firms producing zero units is a unique candidate for Nash

equilibrium. To prove that indeed it is, we have to show that firm 0 (or for that matter any inactive profit-maximizing firm) does not have an incentive to choose a strictly positive amount of output. Note that

$$Q^* = 60, \quad P^* = 72 - 60 = 12$$

If firm 0 chooses $q_0 (> 0)$ units of output while 10 profit-maximizers choose 6 units each, we get $P = 12 - q_0$ and

$$\pi_0 = (12 - q_0)q_0 - \frac{q_0^2}{2} - k = 12q_0 - \frac{3q_0^2}{2} - 54 < 0$$

for all $q_0 > 0$.

Now let us turn to firm 0. Assume that it chooses q_0 to maximize welfare which is consumer surplus plus profits less eQ . We continue with the same numbers in the previous example (i.e. $z = 72, K = 54$). When $e \leq 3$,

$$q_0^* = 6, \quad q_1^* = \dots = q_9^* = 6,$$

and the remaining firms choosing zero units of output constitute a Nash equilibrium. We have replaced a profit-maximizing firm with a welfare-maximizing firm. Observe that the number of active firms and output per firm is same as before. Thus, aggregate outcomes are the same as before, i.e., $Q^* = 60$ and $P^* = 72 - 60 = 12$. Since P^* and q^* remain the same as before, active profit maximizers earn zero profits as before. So does firm 0 since it also faces the same price and chooses the same level of output as other profit-maximizing firms. Note that, at this configuration, profits are zero, consumer surplus (CS) is $\frac{Q^{*2}}{2} = 1800$ and disutility due to negative externality is $-eQ^* = -60e$. Welfare when $q_0 = 6$ is given

$$W|_{q_0=6} = 1800 - 60e.$$

Can firm 0 achieve higher welfare by choosing $q_0 \neq 6$ and yet maintain $\pi_0 \geq 0$. Suppose $q_1 = q_2 = \dots = q_9 = 6$. For $q_0 > 0$, firm 0's profit is

$$\pi_0 = (18 - q_0)q_0 - \frac{q_0^2}{2} - 54$$

which is strictly negative for all $q_0 > 0$ unless $q_0 = 6$. Thus, firm 0's choice is effectively between $q_0 = 0$ and $q_0 = 6$. When $q_0 = 0$ and $q_i = 9$ for $i \in \{1, 2, \dots, 9\}$ we have $Q = 54$ and $P = 72 - 54 = 18$. Consumer surplus decreases from 1800 to 1458. Aggregate profits however increases from zero to 324. Welfare when $q_0 = 0$ is given

$$W|_{q_0=0} = 1782 - 54e.$$

Observe that $W|_{q_0=6} \geq W|_{q_0=0}$ whenever $e \leq 3$. Thus, for all $e \leq 3$, $q_0 = q_1 = \dots = q_9 = 6$,

constitute a Nash equilibrium.

Two remarks are in order. First, in the example described above, there are other Nash equilibria where $q_0^* \notin \{0, 6\}$ and $n^* \notin \{9, 10\}$. Stackelberg environment narrows down the set of equilibria. Our preliminary finding suggests that firm 0 can enjoy strictly positive profits as a Stackelberg leader despite free entry of profit-maximizers. Second, the line of argument presented here—replacing a profit maximizer with a welfare maximizer—does not necessarily work for all objective functions. Suppose firm 0 chooses q_0 to maximize $\tilde{\pi}_0 = \pi_0 - eq_0$ subject $\pi_0 \geq 0$. The term $-eq_0$ in the objective function reflects social responsibility. Note $q_0 = 0$ ensures $\pi_0 = 0$ as well as $\tilde{\pi}_0 = 0$. Alternatively, assuming $q_1 = q_2 = \dots = q_9 = 6$, firm 0 can choose $q_0 = 6$ as that is the only strictly positive quantity level that yields non-negative profits. However

$$\tilde{\pi}_0|_{q_0=6} = \pi_0 - eq_0 = -6e < 0$$

which is strictly lower than $\tilde{\pi}_0|_{q_0=0} = 0$. Unless the firm is legally required to choose $q_0 > 0$, it would rather choose $q_0 = 0$ as it feels socially responsible for its action.

In ongoing work, we are extending the analysis to accommodate a larger class of demand and cost functions, general objective functions and alternative market environment (e.g., differentiated Bertrand)⁹

C.3 Ongoing survey of the empirical literature

In this section, we outline the empirical methods and results used to classify firms, investors or managers as acting according to the objective functions from the maximization problems outlined in Section 4.2. We consider four empirical methods, which we outline in their respective sections below: reduced-form power-based approaches, reduced-form incentive-parameter-based approaches, structural models and case studies. For each method, we assess whether alternative objective functions are considered as alternative explanations for the results. Our approach to this assessment is method-dependent and, therefore, will be outlined for each method further below. From our empirical survey, we highlight the following three results. First, similar to the theoretical literature, papers almost always compare their objective of interest to profit maximization without considering alternative objective functions, or, where alternative objective functions are considered as alternative explanations, do not perform tests to separate these alternative objective functions. Second, in light of this and since, as we will show, there are mixed results in the empirical literature for every objective function, the only objective function that may be rejected is short-term profit maximization. Third, it does not appear any objective function could explain all of the results. Given these three results, the classification problem appears to remain largely an open theoretical and empirical problem.

⁹Details are available on request.

C.3.1 Reduced-form approaches

There is a considerable number of empirical papers that are reduced-form. To effectively deal with this amount of literature in the space we have, we split reduced-form empirics into two common approaches we observed in the literature; power-based and incentive-parameter-based approaches. Within these approaches, we then focus on highly-cited, recent papers from the literature for each objective function.

C.3.1.1 Power-based approaches

In the reduced-form empirical literature adopting power-based approaches, the key relationship of interest is between firm, f , behavior, Y , at time t , Y_{ft} , and the power (or control or influence), ρ , of an agent or agents of interest, usually an investor or group of investors, A , at the firm at time t , ρ_{Aft} . The typical econometric specification is given by:

$$Y_{ft} = \beta \rho_{Aft} + \mathbf{X}\beta + \epsilon_{ft},$$

where \mathbf{X} is a vector of controls, including fixed effects, ϵ_{ft} is the error term, and β is the coefficient of interest. Papers then draw conclusions about the objective function of the agent of interest based on the sign and statistical significance of β and a predicted sign for β based on the objective function of interest in the paper.

As an example, consider Dyck, Lins, Roth, and Wagner (2019), who study the effects of institutional investors on firm-level corporate social responsibility through institutional investor ownership. The core econometric specification in Dyck, Lins, Roth, and Wagner (2019) is given by:

$$\text{Log}(\text{Score}_{it}) = \alpha + \beta X_{it-1} + \gamma' Y_{it-1} + \epsilon_{it}$$

where i indexes firms, t indexes years, $\text{Log}(\text{Score}_{it})$ is the firm-level CSR score as measured by environmental ('E') and social ('S') scores, α is an intercept term, X_{it-1} is institutional investor ownership, Y_{it-1} is a set of control variables and ϵ_{it} is the error term. Based on estimates of β that are positive and statistically significant, Dyck, Lins, Roth, and Wagner (2019) then conclude "we provide new evidence that institutional investors push for stronger firm-level E&S performance around the world. That is, firms are stepping up their E&S performance because investors are asking for it."

The intuition of the power-based method appears to be that β carries information about the preferences of the agent of interest and, that, as ρ_{Aft} increases, the agent of interest should get more of what they want (and vice versa). To accommodate more concrete discussion of the results from studies using the power-based approach, we follow the model presented in

Chapter 3 for this approach, which implies that:

$$\beta = E[Y_{Aft} - Y_{Bft}]$$

where Y_{Aft} is the most-preferred firm choice of the agent of interest, A , at firm f at time t , and Y_{Bft} is the most-preferred firm choice of a benchmark agent, B , at firm f at time t . Based on our reading of the literature, it seems most common for Y_{Bft} to be assumed to be a (short-term) profit maximizer. We therefore also make this assumption.

We now provide results from each of the literatures.¹⁰ In the literature on social responsibility, two highly cited papers are Dyck, Lins, Roth, and Wagner (2019) and Chen, Dong, and Lin (2020). Both Dyck, Lins, Roth, and Wagner (2019) and Chen, Dong, and Lin (2020) investigate the effect of institutional investors on investees' corporate social responsibility. In both papers, the ability of institutional investors to influence firm behavior is proxied by institutional investor ownership¹¹ and corporate social responsibility is measured by CSR scores¹². Both studies use the the econometric specification in Equation C.3.1.1 and neither explore the possibility of objectives other than social responsibility for their results, which could plausibly be explained by long-term profit maximization, stakeholder theory or, to the extent that CSR scores are linked to the reduction of negative spillovers from production, common ownership.¹³

Recent examples from the literature on long-term profit maximization include Gloßner (2019), Kim, Kim, Kim, and Park (2019) and Dimson, Karakaş, and Li (2023).¹⁴ Gloßner (2019), Kim, Kim, Kim, and Park (2019) and Dimson, Karakaş, and Li (2023) all investigate the effects of long-term investors on firms' CSR (or E&S) performance, generally finding that long-term investors encourage CSR. Surprisingly, Gloßner (2019) and Kim, Kim, Kim, and Park (2019) do

¹⁰We are unaware of any papers that investigate stakeholder theory for shareholders or managers using power-based approaches. Empirical papers on stakeholder theory are, therefore, not covered in this section. For a related literature, see the literature on stakeholder salience (for a recent review, see Wood, Mitchell, Agle, and Bryan, 2021). Stakeholder salience appears to focus on managers' perceived importance of stakeholders other than investors, where importance is based on the power, legitimacy and urgency of a stakeholder.

¹¹Chen, Dong, and Lin (2020) also use measures of shareholder attention.

¹²Dyck, Lins, Roth, and Wagner (2019) use environmental and social scores from the Thomson Reuters ASSET4 ESG database and Chen, Dong, and Lin (2020) use CSR strengths and weaknesses from the MSCI ESG KLD database

¹³A more recent paper that is also subject to these issues is Hwang, Titman, and Wang (2022).

¹⁴It is not entirely clear in Dimson, Karakaş, and Li (2023) which objective is being tested. On the one hand, Dimson, Karakaş, and Li (2023) claim in their abstract to be studying "long-term shareholders", whilst on the other, they claim to be studying "universal owners", and "responsible" owners and investors in various other sections of their paper. Strictly speaking, they study coordinated engagements by signatories of the United-Nations-supported Principles for Responsible Investment ('PRI'). Signatories of the PRI agree to six principles, including to "incorporate ESG issues into their investment analysis and decision-making", and the statement that "we believe that environmental, social, and corporate governance (ESG) issues can affect the performance of investment portfolios (to varying degrees across companies, sectors, regions, asset classes and through time)" PRI (2024). Given the mention of investment portfolios, it may also be that signatories of the PRI act as common owners in so far it is consistent with their "fiduciary responsibilities".

not appear to recognize that their results are potentially attributable to social responsibility, stakeholder theory, or common ownership, whilst Dimson, Karakaş, and Li (2023) could be seen as implicitly recognizing the potential for their results to be attributed to universal ownership.

Finally, we discuss the results for common ownership. Since common ownership appears to be dominated by incentive-parameter-based approach, the only papers that use the power-based approach, to the best of our knowledge, and might be considered part of the common ownership literature are He and Huang (2017) and Azar, Duro, Kadach, and Ormazabal (2021). He and Huang (2017) investigate the effect of within-industry cross-ownership on the product market behavior and performance of firms. The results of He and Huang (2017) for market share growth, improved profitability, explicit coordination and innovation productivity could be explained by socially responsible investment, long-term profit maximization or stakeholder theory (as outlined in Section 4.3.1). Azar, Duro, Kadach, and Ormazabal (2021) examine the relationship between the institutional ownership of the "Big 3" asset managers (BlackRock, StateStreet and Vanguard) and firm-level greenhouse gas emissions. Overall, they find that the Big 3 ownership has a negative association with firm-level emissions, which is consistent with the incentives, including common ownership, they observe in their dataset. Azar, Duro, Kadach, and Ormazabal (2021) do potentially recognize social responsibility as an alternative motivation, albeit through the attraction of investment clients with such motivations. However, Azar, Duro, Kadach, and Ormazabal (2021) do not provide empirical evidence that differentiates between these motivations, nor do they explore the possibility of long-term profit maximization or stakeholder theory.

C.3.1.2 Incentive-parameter-based approaches

In the reduced-form empirical literature adopting the incentive-parameter-based approach, the key relationship of interest is between firm behaviour at time t , Y_{ft} , and firm-level or agent-level, A , incentive parameters, δ_{A_jft} , where j indexes incentive parameters. Theoretically, these incentive parameters are typically applied to future payoffs or stakeholder group A 's payoffs and are what we call discount factors in Section 4.2.¹⁵ The typical econometric specification is given by:

$$Y_{ft} = \beta\delta_{A_jft} + \mathbf{X}\boldsymbol{\beta} + \epsilon_{ft}, \quad (\text{C.1})$$

where \mathbf{X} and ϵ_{ft} are as defined in Section C.3.1.1, and δ_{A_jft} is usually calculated as a weighted, w_i , function of individual agent, i , incentive parameters, δ_{ijft} :

$$\delta_{A_jft} = \sum_{i \in A} w_i \delta_{ijft}, \quad (\text{C.2})$$

¹⁵In applied empirics, however, proxies for these incentive parameters are often used, which implies measurement error. Whilst measurement error may be an important consideration in weighting the validity of applied empirical work, we, for simplicity, assume it is not an issue for our purposes.

Conclusions about the relevance of the incentive parameter to, and, therefore, the objective function of, the agents of interest are then made based on the sign and statistical significance of β .

As an example, consider Antón, Ederer, Giné, and Schmalz (2023), who study the effects of common ownership incentives on the wealth-performance sensitivity of compensation schemes for CEOs. The core econometric specification in Antón, Ederer, Giné, and Schmalz (2023) is given by:

$$WPS_{ijzt} = \theta CO_{it} + \xi X_{ijz_4t} + \eta_{z_2t} + \nu_i + \epsilon_{ijzt}$$

where i indexes firms, j indexes managers, z_2 represents industries at the two-digit level, z_4 represents industries at the four-digit level, WPS_{ijzt} is a measure of the wealth-performance sensitivity of CEO compensation, CO_{it} is a measure of common ownership incentives,¹⁶ X_{ijz_4t} is a vector of control variables, η_{z_2t} are industry-year fixed effects, ν_i are firm fixed effects and ϵ_{ijzt} is the error term. Based on estimates of θ that are negative and statistically significant, Antón, Ederer, Giné, and Schmalz (2023) conclude "[f]irm-level common ownership has a large negative effect on the performance sensitivity of managerial incentives."

Assuming β is consistently estimated, the classification problem may not arise. This is because the incentive parameters may characterize particularly types of objective functions. However, if the incentive parameters of other objective functions that could potentially explain the results are omitted, then the classification problem may arise. When assessing the literature applying the incentive-parameter-based approach, we therefore assess whether measures of the incentive parameters from other objective functions are included in the econometric specification.

To see how this problem may arise, suppose there is an omitted incentive parameter that contributes to omitted variable bias. Specifically, suppose there is another incentive parameter $\delta_{A_j' ft}$ calculated as:

$$\delta_{A_j' ft} = \sum_{i \in A} w_i \delta_{A_j' ft} \quad (\text{C.3})$$

that also affects firm behavior, Y_{ft} . To capture this in Equation C.1, suppose $\epsilon_{ft} = \gamma \delta_{A_j' ft} + \epsilon'_{ft}$ where $\gamma \neq 0$ and $E[\epsilon'_{ft} | \delta_{A_j' ft}, \mathbf{X}] = 0$. Since $\delta_{A_j' ft}$ and $\delta_{A_j' ft}$ use the same set of weights, it seems reasonable to assume that $E[\delta_{A_j' ft} | \delta_{A_j' ft}, \mathbf{X}] \neq 0$. Thus, in Equation C.1, $E[\epsilon_{ft} | \delta_{A_j' ft}, \mathbf{X}] \neq 0$ so that β is no longer consistently estimated.

In response to this argument, it might be suggested that instrumental variables (or difference-in-differences) could be and are (is) used in the literature to address this problem. We, however, believe that finding valid instrumental variables is unlikely. We present our argument from two different perspectives on the incentive parameters and weights. First, suppose the

¹⁶Antón, Ederer, Giné, and Schmalz (2023) use many measures of common ownership, including measures that correspond to the discount factors in Section 4.2.

incentive parameters and weights are "exogenously" given variables that are latent but real. Since δ_{Ajft} and $\delta_{A'jft}$ are both functions of the weights, w_i , the instrumental variables must affect the exogenously given incentive parameters and not the weights. However, it is often shocks to weights (or incentive parameters that are functions of the weights as in common ownership) that are used as instrumental variables. Thus, unobserved incentive parameters, or the error terms for the proxies for these omitted incentive parameters, are likely affected by the instrumental variables used, rendering the instrumental variables invalid. Second, if instead the incentive parameters and weights are seen as measurements, or statistics, derived from a structural model using observables that act as summary descriptions of the observed phenomena, then incentive parameters and weights may be functions of all observables, including the instrumental variables. Thus, the instrumental variables would affect the omitted incentive parameters for the agent of interest, and, therefore, β would not be consistently estimated in Equation C.1 when potentially important incentive parameters are omitted.

We now turn to some examples from the literatures for each objective function, beginning with stakeholder theory.¹⁷ These papers include Flammer and Kacperczyk (2016), Bettinazzi and Zollo (2017) and Bettinazzi and Feldman (2021). In these papers, the authors investigate the effect of stakeholder orientation¹⁸ on firm's acquisition performance, divestiture choices and innovation levels. For each of these papers, the incentive parameters of other objective functions are not considered as alternative explanations for the results. Furthermore, Bettinazzi and Zollo (2017) and Bettinazzi and Feldman (2021) do not include measures of incentive parameters from alternative objective functions in their econometric specifications, whilst the constituency statutes used for differences-in-differences in Flammer and Kacperczyk (2016) would affect every firm incentive parameter, not only stakeholder orientation.

Next is common ownership. Recent, highly cited empirical papers in the common ownership literature that utilize the incentive-parameter-based approach include Gilje, Gormley, and Levit (2020), Boller and Scott Morton (2020) and Antón, Ederer, Giné, and Schmalz (2023). Similar to the papers in the previous section, none consider whether their results could be driven by alternative objective functions, such as a combination of negative externalities and socially

¹⁷To the best of our knowledge, there have been no studies for social responsibility that follow the incentive-parameter-based approach other than Cheng, (Helen) Wang, and Wang (2022), who we discuss further below as an example where multiple incentive parameters are included in the econometric specification. We therefore do not include a section on social responsibility. For a potentially related literature, see, for example, the literature using CSR scores as independent variables in Gillan, Koch, and Starks (2021). Using behavioral proxies, such as CSR scores, for incentive parameters is the approach taken in the stakeholder theory and long-term profit maximization literatures.

¹⁸Whilst those in the stakeholder orientation literature do not appear to use the concepts of discount factors or incentive parameters in relation to stakeholder orientation, we classify this approach following as an incentive-parameter-based approach because stakeholder orientation appears to reflect a similar concept to incentive parameters and discount factors. For example, Bettinazzi and Feldman (2021) define stakeholder orientation as "the extent to which a firm's management focuses attention on and integrates the interests of multiple stakeholders in its decision-making," which can be measured using discount factors and incentive parameters.

responsible investors. Furthermore, none of these papers include measures of incentive parameters from alternative objective functions in their econometric specifications.

Finally, in the case of long-term profit maximization, there is Gloßner (2019) and Kim, Kim, Kim, and Park (2019), both cited in Section C.3.1.1, also use measures of incentive parameters for long-term profit maximizers. Specifically, Gloßner (2019) and Kim, Kim, Kim, and Park (2019) both use investor's portfolio turnover (i.e. trading behaviour) as a measure of an investor's investment horizon and regress firm-level CSR behaviours on investor portfolio turnover. For similar reasons to those given in the previous section, however, their results could be attributable to social responsibility, stakeholder theory, or common ownership. Furthermore, they do not include incentive parameters from alternative objective functions in their econometric specifications.

It should be noted, however, that some papers take steps in addressing our criticism of the incentive-parameter-based approach by including more than one incentive parameter in their analysis. These include Azar and Vives (2021b) and Cheng, (Helen) Wang, and Wang (2022). Azar and Vives (2021b) include both intra- and inter-industry common ownership incentive parameters in their regressions. Thus, Azar and Vives (2021b) results, which are in the airline industry, may still be driven by incentive parameters from other objective functions. Cheng, (Helen) Wang, and Wang (2022) measure common ownership incentives, long-term profit maximizer incentives and social responsibility incentives through various measures. However, Cheng, (Helen) Wang, and Wang (2022) do not include these incentives in a single specification and the specifications they do use essentially involve interaction terms with common ownership.^{19,20} Thus, despite constructing a wide array of measures, Cheng, (Helen) Wang, and Wang (2022) also do not test multiple theories. Furthermore, it is also possible that their results are attributable to stakeholder theory (which would involve a set of incentive parameters for which they do not appear to have measures).

C.3.2 Structural approaches

To the best of our knowledge, the recent empirical papers applying a structural approach are from the common ownership literature only. These papers include Kennedy, O'Brien, Song,

¹⁹Cheng, (Helen) Wang, and Wang (2022) use measures of common ownership, investment horizons and an investor's portfolio-level CSR behavior to sort firms into high and low categories for each measure. The categories for investment horizon and CSR are not regressed separately from the categories for common ownership; that is, they are interaction terms. See Table 11 in Cheng, (Helen) Wang, and Wang (2022) for more detail.

²⁰Whilst outside the scope of our argument it is also the case that the approach of Cheng, (Helen) Wang, and Wang (2022) may be subject to an important source of measurement error. This measurement error arises from explaining firm-level CSR behaviour as a function of common ownership incentives and investment horizon, then using aggregated firm-level CSR behaviour as a proxy for investor's social responsibility. Presumably, such a proxy for investor's social responsibility is also driven by common ownership incentives and investment horizons. Therefore, it seems plausible that the measurement error in this proxy is correlated with common ownership incentives and investment horizons.

and Waehrer (2017), Park and Seo (2019), Backus, Conlon, and Sinkinson (2021) and Azar and Ribeiro (2022).²¹ Each approach involves estimation of a conduct parameter which captures the degree to which common ownership incentives, which are measured using ownership data, are internalized in firm behavior. Park and Seo (2019) and Azar and Ribeiro (2022) find supporting evidence for firms internalizing common ownership incentives, whilst Kennedy, O'Brien, Song, and Waehrer (2017) and Backus, Conlon, and Sinkinson (2021) do not.²²

Since, for similar reasons given for the common ownership theory papers in Section 4.3.1, much of the behavior could be explained by incentive parameters that remain unmeasured or untested, the behavior could be explained by investors following other objective functions. For concreteness, we briefly outline how this could be so for each paper. To do so, we group papers into those that focus on the airline industry and those that do not. Those that focus on the airline industry include Kennedy, O'Brien, Song, and Waehrer (2017), Park and Seo (2019) and Azar and Ribeiro (2022). Since the airline industry's contributions to greenhouse amount to total greenhouse gas emissions and the airline industry's opportunities to mitigate emissions is limited, much of the anti-competitive incentive captured by Kennedy, O'Brien, Song, and Waehrer (2017), Park and Seo (2019) and Azar and Ribeiro (2022) could be attributable to, for example, socially responsible investors encouraging airlines to reduce emissions. Since airlines' opportunities to mitigate emissions were almost non-existent during the time periods studied in these papers, the only way airlines could reduce emissions was to increase flight prices and reduce the number of flights. For similar reasons, long-term profit maximizers and those following stakeholder theory may encourage firms to act in a similar way. Backus, Conlon, and Sinkinson (2021), in contrast, model the ready-to-eat cereal industry, finding that their results are most consistent with, what is in our framework, short-profit maximization (Backus, Conlon, and Sinkinson (2021) refer to short-profit maximization as own-profit maximization). Arguably, the results of this paper could be replicated by long-term profit maximization, long-term, broad common ownership or stakeholder theory.²³

C.3.3 Case studies

To close the section on empirics, we present some brief results on case studies, which are a particularly prominent method in the law and management literatures. This component of

²¹We do not include Asai and Charoenwong (2022) in this section since their structural model does not include a conduct parameter related to common ownership incentives. Rather, Asai and Charoenwong (2022) rely on a reduced-form analysis to identify behavior that they attribute to common ownership incentives.

²²It should be noted that the results of Kennedy, O'Brien, Song, and Waehrer (2017) are contested by Azar, Schmalz, and Tecu (2018) and, whilst their evidence is in favor of own-profit maximization, Backus, Conlon, and Sinkinson (2021) cannot reject low levels of internalization of common ownership incentives.

²³Given the results of Backus, Conlon, and Sinkinson (2021) suggest that medium to high levels of internalization of common ownership can be rejected, it seems that their results are less able to be explained by the presence of negative externalities and socially responsible owners. However, it may also be that the negative externalities are relatively negligible in the ready to eat cereal industry.

the empirical survey is the least developed. Therefore, we present only the set of results that permit our conclusion that no maximization problem or objective function can fully explain the set of results presented. Given that papers in Sections C.3.1 and C.3.2 provide evidence for rejecting short-term profit maximization and common ownership, the remaining maximization problems and objective functions relate to social responsibility, long-term profit maximization and stakeholder theory.

Each of these maximization problems and objective functions are rejected by the results of Bebchuk, Kastiel, and Tallarita (2020), Bebchuk and Tallarita (2022), Bebchuk, Kastiel, and Toniolo (2023) and Bebchuk, Kastiel, and Tallarita (2023). This series of papers investigates the benefits and costs of acquisitions for stakeholders. A primary result from these papers are that stakeholders were generally "pushed ... under the bus" (Bebchuk, Kastiel, and Toniolo, 2023). It should also be noted, however, that directors also sometimes received unusual benefits, indicating that, whilst profit maximization may require that directors participation constraints must be satisfied in this case, profit was not maximized. Therefore, profit maximization is also invalidated. Finally, many of the pledges that directors were considered to have violated (Bebchuk, Kastiel, and Toniolo, 2023) could also be perceived as commitments to social responsibility, therefore invalidating social responsibility.

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