Environmental Activism, Endogenous Risk, and Stock Prices*

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August 31, 2022

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Abstract

We consider a three-period economy with two firms, green and brown, where the brown firm generates pollution. The availability of a costly pollution-abatement technology is revealed in period 2. Without activism, the brown firm's manager, who maximizes shareholder value, will not adopt the technology even though it is socially optimal to do so. We consider three activist strategies: Exit (divestment of shares), Boycott (of goods), and Voice (proxy-voting). Boycott is more effective than Exit. Voice is most effective, requiring fewest activists provided the brown firm is small with shares having equal voting power. The personal cost to activists can be higher for Voice. When the number of activists is large but too low to be effective, the green share's price will rise and the brown share's price will fall when the technology becomes available. An unanticipated jump in the number of activists can move the economy from one equilibrium to another, making activism effective. If this happens, the green share's price will fall with a much smaller further decline in brown share's price.

JEL classification codes: D62, G12, L21

Keywords: Activism, value maximizing, ESG, endogenous risk

1 Introduction

Attention to environmental, social, and governance issues in investment decisions among professional money managers has become widespread since the launch of the Principles for Responsible investment in 2006 by the United Nations and the widespread public concern about the use of fossil fuels and their role in global warming. Such attention has led to activism through divestment,[1] boycotts by consumers, and use of proxy voting campaigns to wean firms away from fossil fuels and toward development of greener energy sources. Legislative actions have led to direct subsidies, tax credits and grants to consumers and producers for qualifying renewable energy projects and establishment of markets for trading carbon credits.[2]

The effectiveness of activism, especially through divestment, has been the subject of much debate. However, some skeptics have moved towards activism. In a Financial Times interview in September 2019, Bill Gates said that "[d]ivestment, to date, probably has reduced about zero tonnes of emissions. It's not like you've capital-starved [the] people making steel and gasoline." Later, however, he stated that in 2019 both he and the Gates Foundation's endowment "divested all ... direct holdings in oil and gas companies."[3] Further, "[p]ension funds and other traditional investors in private-equity energy funds have cut their allocation to the conventional-energy sector to as little as 1% of their portfolios. . . . Meanwhile, most investors and lenders refuse to be involved in coal companies despite surging energy prices."[4]

We examine the effects of activism on share prices and managerial behavior, considering a three-period economy where a fraction k of agents are environmental activists, and there are two types of firms, green and brown. The green firm does not pollute, but the brown firm does, causing environmental damage affecting all agents in the economy. With some probability, a technology becomes available that will give the brown firm the option become

[1] According to divestmentdatabase.org, as many as 1,497 institutions with a combined assets under managing of about \$39.88 trillion have committed to divesting or excluding some type of fossil fuel related investments in October 2021.

[2] The Baker-Schultz carbon dividends plan that has bi-partisan support and the Waxman-Markey bill of 2009 are examples of legislative action.

[3] Bloomberg, February 14, 2021.

[4] "Investor Shift From Fossil Fuels Leaves Surging Market to Smaller Players", Wall Street Journal, October 13, 2021.

green.

In this setting we consider three strategies for activists, which we treat as mutually exclusive:[5] Exit (selling brown shares), Boycott (not purchasing goods from brown firms), and Voice (holding brown shares and voting in favor of the manager adopting green policies). We characterize equilibria as a function of k, the fraction of activists in the economy. We find that there are two thresholds, $\bar{k}$ and $\bar{\bar{k}}$, with $\bar{k} \leq \bar{\bar{k}}$ for Exit and Boycott (the thresholds generally differ by strategy). When $k \leq \bar{k}$ (low k), activists have no impact on prices. When $\bar{k} < k \leq \bar{\bar{k}}$ (intermediate k), Exit and Boycott have similar effects. They both adversely affect the targeted brown firm's stock price. However, the price effect is not large enough to induce the brown firm to become green.[6] When $k > \bar{\bar{k}}$ (high k), activists succeed. We show that Boycott is more effective than Exit in the model in that the thresholds can be lower under Boycott. In the case of Voice, there is no $\bar{k}$, but only $\bar{\bar{k}}$, i.e., k can only be low or high, because activists can enforce the adoption of green technology once they hold the majority of the brown firm's shares. Voice can be more effective than the other two strategies under certain conditions.[7] In general, activists pay a price for their activism: under Exit, when they sell brown shares they do so at a low price; under Boycott, they pay more for green goods; and under Voice, when they accumulate brown shares they may have to pay a high price.[8] It is important to keep in mind that taxation and Boycott will be applicable to all firms irrespective of whether they are public or private companies, whereas Exit and Voice are applicable only for firms with publicly traded shares. However, Boycott also requires the ability to identify goods by their origin. We assume that the emissions tax is low and hence the green technology will not be adopted without the intervention of activists.[9]

[5] Mutual exclusivity ignores complementarities — for example, in practice agents who exit would presumably boycott as well if they could discern origins of goods.

[6] We assume that activists do not collaborate. As documented in Dimson et al. (2015), collaboration among activists increases effectiveness.

[7] We assume that shares have equal voting power. In reality, a firm may have different classes of shares, with some share classes having more votes even though all shares have the same cash flow rights. Meta (formerly Facebook) is an example with class A shares (one vote per share) and class B shares (with 10 votes per share) with the same cash flow rights.

[8] Hwang et al. (2021) document that firms after revelation of higher SRI ownership have negative stock returns and firm values come down after anticipated increase in CSR activities.

[9] Golosov et al. (2014) develop a general equilibrium model and find that the optimal tax on fossil fuel should be higher than the median estimates in the literature. Nordhaus (2019) argues that the price of CO_2 is much lower than it is supposed to be.

Uncertainty concerns the existence of a technology to convert brown production to green. As an example, consider production facilities that are hydro-powered in one area, with otherwise identical facilities elsewhere that are powered by coal or oil. Converting the latter requires that a feasible cost-effective transition be possible. This could involve adoption of renewable power, or the installation of carbon capture technology. It is important to keep in mind that many such transitions can only occur at scale; electric vehicles, for example, require a charging network and renewable power requires both low priced power generation and an electric grid that can adapt to fluctuations in generation.[10]

We show that activism can introduce endogenous risk when the equilibrium involves the brown firm manager following a mixed strategy of technology adoption. When activists follow the Exit strategy, although the unconditional returns from period 1 to 2 are the same for both shares, conditional on the green technology being available the green shares are riskier in the near term and earn a short-term conditional risk premium, while brown shares are riskier in the long term and earn a risk premium.

2 Related Literature

There is a vast literature on socially responsible and sustainable investing, and we refer the interested reader to several survey articles. Kitzmueller and Shimshack (2012) synthesize the literature on corporate social responsibility and explore why it exists. Besley and Ghatak (2018) review the literature on the role of incentives in providing goods and services that have returns with significant social components. Matos (2020) surveys the literature from the perspective of industry practitioners. Christensen et al. (2021) review the literature on economic effects of mandated disclosure for corporate social responsibility and sustainability. Our paper contributes to this broader literature on corporate social responsibility, emphasizing environmental responsibility and focusing on implementation mechanisms.

How to achieve the socially responsible activities by private firms has been a widely discussed issue in the literature. Besley and Ghatak (2017) consider three types of organizations,

[10] The solar cell was first developed in 1883 by American inventor Charles Fritts. In the last 40 years, the cost of photovoltaic modules has declined by 99%, with the decline attributable to reduced input costs, economies of scale, government-funded R&D, and subsidies. See Kavlak et al. (2018).

social enterprise, non-profits, and for-profits, and the important role of citizen-managers with non-selfish preferences in running firms with flexible missions. Chowdhry et al. (2019) examine a project that produces profits and a social good at the same time, with two types of investors, one motivated by profit and another by social impact.[11] They show that when the project's social impact is large, joint financing by both types of investors can be mutually beneficial. In our model, too, we consider a case of two types of investors, one who care only about profits and another who care about social goods as well, but our interest is in examining the effectiveness of various strategies available to those who care about social goods.

Various approaches to socially responsible investors' behavior have been explored in the literature. Gollier and Pouget (2014) examine a model where some investors are socially responsible and take externalities into account, but their focus is on large investors. They show that a large activist investor can profit by buying out a non-socially responsible firm and selling it after converting it into a responsible one. Heinkel et al. (2001) assume that some investors do not want to hold shares of firms with negative externalities and consider the impact of their Exit on firms' share prices and show how that affects firms' decisions to reform. Pástor et al. (2021) extend the framework in Heinkel et al. (2001) so that investors have smooth preference for consumption good as well as the non-pecuniary flow of benefits to investing in shares that depend on their ESG characteristics. They derive a linear beta model for the expected return on financial assets.[12] Goldstein et al. (2022) also consider two types of investors — ESG and non-ESG. However, they focus on the informational content of asset price from which outside investors can learn the monetary prospects of a firm. By contrast, we exploit the incentivizing aspects of asset prices. Our main goal is to study the effect of activist strategies and how it induces the firm value maximizing manager to adopt the green technology.

[11] Bansal et al. (2022) argue that investors' concern about socially responsibility is higher during good times. Riedl and Smeets (2017) and Barber et al. (2021) provide the evidence of investors' social preferences. Starks et al. (2020) find that the use of ESG considerations are influencing investment decisions of investors with longer investment horizons – in both US mutual funds as well as institutional investors, which means that investors' sensitivity to ESG issues while making portfolio choice decisions is here to stay.

[12] Pedersen et al. (2021) develop a four-factor equilibrium asset pricing model when an asset's ESG score conveys information about the firm's fundamentals in addition to its contribution to negative social externalities.

In a closely related paper, Broccardo et al. (2022) model agents as deriving utility by consuming the good, as well as the aggregate welfare of agents in the economy affected by their decision.[13] Our conclusions are similar to theirs: Exit and Boycott are less effective than Voice in inducing firms to act in socially responsible manner. We also show that the effectiveness of Voice depends on the relative size of the two firms and Voice is least effective when the brown firm is large. Berk and van Binsbergen (2022) also confirm empirically that the price effects of disinvestment are likely too small for exit o affect firm behavior.

We consider an economy where green and brown products are perfect substitutes and a fraction of agents restrict themselves in consumption or investment decisions. This setup is in line with the intuition of Aghion et al. (2020), the synergetic interaction between market competition and socially responsible agents. While Aghion et al. (2020) consider only boycott by consumers, we extend the activist strategies and compare their effects across Exit, Boycott, and Voice.

In our model, agents' utility function depends on goods consumed as well as the public bad, which can be thought of as a characteristic of the brown firm as in Pástor et al. (2021). However, the public bad in our model depends on the brown firm's equilibrium output and technology choice, and the agents are infinitesimal so that they do not internalize the public bad into their decisions, unlike Oehmke and Opp (2020). As in Heinkel et al. (2001), some agents are socially responsible and will not invest in brown firm shares when they follow the Exit strategy. Given our interest in examining how different activist strategies induce the brown firm manager to take the socially right action, we abstract away from risk and model firms' outputs as being certain, unlike in Heinkel et al. (2001) and Pástor et al. (2021). The only exogenous uncertainty is about the availability of a technology to convert the brown firm into a green firm, at a cost.[14] We do not consider green mandates imposed on the firms as in Hong et al. (2021), either. We find that legislative action by taxing public bad can attain what can also be achieved by activism using Exit, Boycott, or Voice strategy, provided that there are sufficient activist agents in the economy.[15] In our framework, when there are

[13] Heeb et al. (2022) finds the evidence that investors care about whether the investments are sustainable, but not how much the impacts are.

[14] We introduce an endogenous risk in Section IA.4 due to the brown firm manager following a mixed strategy of technology adoption.

[15] Gantchev et al. (2021) provide the evidence that a sufficiently large number of investors, even though

enough activist investors, Exit and Boycott will increase the expected return on the brown firm and depress its share price, consistent with the findings in Hong and Kacperczyk (2009), Chava (2014), Pástor et al. (2022), and Bolton and Kacperczyk (2021a).[16]

An important insight from our model is that activism changes the nature of the equilibrium. The brown firm manager compares the brown firm value when the green technology is adopted with the value when not adopted.[17] The scenario with the lower firm value will not be on the equilibrium path, and the out-of-equilibrium prices are never observed.

Activism by socially conscious investors can lead to legislative action, like taxation of brown outputs, and convince other agents in the economy to become activists. Our model does not directly reflect this aspect of reality but leave such features for future research.[18]

The rest of the paper is organized as follows. Section 3 lays out the structure and underlying assumptions of the economy in our model. Section 4 gives a detailed description of the timeline of the model and presents the decision problems of agents and firms. Section 5 defines and solves the equilibrium under each activist strategy. Section 7 summarizes the model and concludes.

3 Structure of the Economy

This section explains the structure of the model. We consider a stylized three-period economy ($t = 1, 2, 3$). A continuum of agents is endowed with the non-storable consumption good in periods 1 and 2. They are also endowed in period 1 with shares in two firms that pay consumable dividends in period 3. Agents consume in all three periods. The only uncertainty concerns the availability of a technology to reduce environmental externalities created by one

they do not have large stakes in the firm, can affect the share price through their E&S preferences and induce the firm to improve E&S policies.

[16]See Röell (2019), Kim and Yoon (2020), Lindsey et al. (2021), and Heath et al. (2021) for other aspects of socially responsible investments.

[17]Albuquerque et al. (2019), Akey and Appel (2019), Naaraayanan et al. (2021), and Bolton and Kacperczyk (2021b) also study the effects of activism on the firms and the economy. Albuquerque et al. (2019) build a model where customers are more loyal to green products, so firm has an incentive to go green. Akey and Appel (2019) empirically show that divestment leads to reduction in emissions due to brown output coming down. Naaraayanan et al. (2021) find that the drop comes from emission reducing technology adoption and not from reduction in output. Bolton and Kacperczyk (2021b) empirically find that greener firms have lower cost of capital, due to institutional investors divesting from brown shares.

[18]See Dunn et al. (2018), Jagannathan et al. (2018), Hsu et al. (2020), and Ardia et al. (2020).

of the firms. For analytical convenience, we abstract away from other risk considerations that affect portfolio choice and stock prices.[19] In addition to examining different strategies for agents, we also impose a tax at rate τ on consumption of goods produced by the polluting firm when the green technology is not used. Tax proceeds are rebated equally across all agents.

Each period in the model serves a distinct purpose. In period 1, agents receive initial share allocations and trade. In period 2, agents learn whether the green technology exists, and they trade again. Finally, in period 3, agents consume output from the firms. The central question is whether the green technology, if it exists, is adopted by the brown firm. Actions taken by the agents have the opportunity to influence this adoption decision.

3.1 Firms and the green technology

There are two firms, one brown (B) and one green (G), each of which has one share outstanding. Firms produce output only in period 3. Consumption goods produced by both firms in period 3 are paid out to the shareholders of the respective firms as liquidating dividends, D_{B3} and D_{G3}. Consumption goods received as dividends are tagged so that agents can identify whether they are from firm B or G. The green firm always converts the intermediate good one-for-one into D_{G3} units of consumption good. Output of the brown firm, by contrast, depends on adoption of the green technology, for which the existence is revealed in period 2. The probability that the green technology exists is p. There are three possibilities:

- **The green technology does not exist.** In this case the brown firm converts D_{B3} units of intermediate goods into D_{B3} units of consumption good. Firm B produces b units of public bad as well, which adversely affects all agents in the economy equally. The scale factor that converts public bad into its consumption equivalent is δ, so that $b = \delta D_{B3}$, which is not a choice variable by agents. Goods produced by the brown firm are taxed at rate τ.

- **The green technology exists but is not adopted.** In this case, production occurs

[19] When there is economy-wide pervasive risk, there will be an additional utility cost to holding concentrated positions by deviating from the market portfolio. This should not directionally affect our main results.

as if the green technology did not exist, but output is tagged, so strategies such as Boycott are feasible. Goods produced by the brown firm are taxed at rate τ.

- **The green technology exists and is adopted.** If the green technology is available and is adopted by firm B, no public bad will be produced when firm B converts its intermediate good to consumption good, but conversion is less efficient: each intermediary good will be converted to $(1-\eta)$ consumption good, where $0<\eta<1$. There is no tax on goods produced by firm B.

3.2 Agents

Agents live 3 periods and have CARA utility with coefficient A, with no time discounting.[20] Consumption by agent i in period t is c_{it}. Per capita consumption of the public bad produced by the brown firm (if it does not adopt the green technology) is b. The lifetime utility of agent i is therefore[21]

$$U_i = -e^{-Ac_{i1}} - e^{-Ac_{i2}} - e^{-A(c_{i3}-b)}. \tag{3.1}$$

Each agent i at birth is endowed with

- θ_{ij0} shares of firm $j, j = B, G$.

- ψ_{it} of the consumption good, received at the beginning of periods $t = 1, 2$. We use ψ_{it} to denote consumable endowments in periods 1 and 2 and D_{B3} and D_{G3} to denote the consumable dividend paid by the brown and green firms in period 3, in which there is no endowed consumption.

- A type, either ESG (the fraction k of agents, $i\in[0,k]$), or $NESG$ (the fraction $1-k$ of agents, $i\in(1-k,1]$). ESG agents care about reducing the creation of public bad even if they incur a personal cost. Throughout the paper, we will use the terms "ESG agents" and "activists" interchangeably.

[20]The main results for our paper are qualitatively identical under CRRA utilities.

[21]In our model, the public bad enters additively in the utility function as in Pástor et al. (2021).

Adoption of the green technology reduces output, so in order to ensure that it can be socially optimal to adopt the green technology we assume that the consumption equivalent of firm B's output of public bad, δD_{B3}, exceeds the loss in output from adoption of the green technology, ηD_{B3}:

$$\delta > \eta. \tag{3.2}$$

If the brown firm does not adopt the green technology when it is available, consumption goods produced by the brown and green firms are distinct and denoted as c_{iB3} and c_{iG3}. Apart from their origin, the two goods are perfect substitutes, so that agent i's total consumption in period 3 is $c_{i3} = c_{iB3} + c_{iG3}$. Consumption goods received as endowments in earlier periods have no labels and are interchangeable.

When ESG and $NESG$ agents have different per-capita endowments, we write aggregate consumption in periods 1 and 2 as

$$\psi_t = k\psi_t^{esg} + (1-k)\psi_t^{nesg}; \qquad t \in 1, 2 \tag{3.3}$$

In the base case, with homogeneous endowment across ESG and $NESG$ agents, we set $\psi_t^{esg} = \psi_t^{nesg}$, and we simply write ψ_1 and ψ_2 to denote aggregate consumption in periods 1 and 2.

Individual consumption and endowments of shares and goods are — c_{i1}, c_{i2}, c_{ij3}, θ_{ij0}, ψ_{i1}, and ψ_{i2} are expressed in terms of *intensity* for an infinitesimal agent i. When all agents are identical, the individual equilibrium consumption intensity c_i^* will be the same for all agents and we will denote this c^* without the subscript i. In that case, aggregate consumption is $\int_0^1 c_i di = c$,where we use the same notation, c, for individual consumption intensity and aggregate consumption. We will also drop the superscript * for notational convenience.

3.3 Markets

Stocks are traded during periods 1 and 2. In period 1, trading of shares takes place after agents learn their type (ESG or $NESG$) and receive their endowment of the consumption good. In period 2, trading in stocks takes place after the uncertainty about the availability of the green technology is resolved. In period 3, trading takes place after the brown firm has decided whether or not to adopt the green technology. Following the adoption decision, liquidating dividends are paid to shareholders, who then consume the dividend. The consumption good is the numeraire in periods 1 and 2, and the consumption good produced by firm G is the numeraire in period 3.

3.4 Activist strategies and behaviors

ESG agents make some decisions without regard for personal cost. We make the following behavioral assumptions:

- **Exit strategy** ESG agents will liquidate all the shares of firm B in period 2 if the green technology is available and is not adopted.**Boycott strategy** ESG agents will avoid the consumption good produced by firm B in period 3 if the green technology is not adopted when available.[22]
- **Voice strategy** ESG agents will liquidate their holdings of shares in firm G and invest the proceeds in shares of firm B in order to participate in a proxy vote in period 1 that directs the management to adopt the green technology if it becomes available.

In any event, we assume that the government levies a tax at rate τ on firm B's output of the consumption good paid out as dividends if the green technology was not used, whether available or not. How the ESG agents will behave is public knowledge. There is only one source of uncertainty in this economy — whether the green technology will be available in period 2.

4 Decision Problem of Individual Agents and Firms

We now describe the consumption-portfolio choice problem of each type of agent. $NESG$ agents choose consumption and share holdings to maximize utility taking the public bad

[22] The Boycott strategy induces a lexicographic preference for the green consumption good. Similarly, the Exit strategy is as if the agents had lexicographic preference for the green firm's shares. By contrast, in Pástor et al. (2021) an agent's preference for a firm's characteristics is continuous.

as given. They value shares of brown and green firms based on their dividends and treat the consumption goods produced by firms B and G as perfect substitutes. ESG agents also maximize utility, but subject to the behavioral constraints outlined in Section 3.4. Throughout, we assume no short-selling of shares.

As with shareholders, there are also $NESG$ and ESG managers. The default firm B manager type is $NESG$. This manager will adopt green technology if doing so maximizes the share price. An ESG manager of firm B, by contrast, will adopt the green technology as long as it exists. Voice provides a mechanism for changing the manager type.

4.1 Timeline

Figure 1 depicts the evolution of events and the decisions the agents and firm managers make over time.

Period 1. Each agent i enters period $t = 1$ (S_1) endowed with θ_{iB0} of firm B's shares, θ_{iG0} of firm G's shares, and ψ_{i1} of consumption good. Given share prices p^s_{B1} and p^s_{G1}, agents choose consumption c_{i1} and shareholdings θ_{iB1} and θ_{iG1}. In the case of Voice, ESG agents sell their green shares (setting $\theta_{iG1} = 0$) to buy brown shares, in hopes of electing a an ESG manager for the brown firm.[23]

Period 2. Each agent i enters period $t = 2$ holding θ_{iB1} shares of firm B, θ_{iG1} shares of firm G, and an endowment of consumption good of ψ_{i2}. The availability of green technology is determined by nature:

- With probability $1 - p$, the green technology is not available (state S_{21}),[24] so there is no decision to be made by Firm B.[25]

- With probability p, the green technology is available (state S_{22}). By default, firm B's manager is $NESG$.

  - In Exit and Boycott, we assume that the $NESG$ manager adopts the green technology (state S_{22A}) only if doing so maximizes the share price at the beginning of

[23]Shareholdings of θ_{ij1} and θ_{ij2} are the holding *intensities* chosen by an infinitesimal agent i.

[24]The first subscript denotes the time period and the second denotes the state.

[25]The state S_{21} helps benchmark share prices when no technology is available and thus period 1 is necessary. Our model has the flexibility to examine technology development/innovation for future work.

period 2. Otherwise, the firm remains brown (state S_{22N}).

  – In Voice, the manager type is determined by an election in period 1, in which a majority vote determines whether there will be a switch to an ESG manager. If the vote is successful, the brown firm will adopt the green technology if it is available.

- In each of the states S_{21}, S_{22N} and S_{22A}, agents choose consumption c_{i2} and shareholdings θ_{iB2} and θ_{iG2} given share prices p^s_{B2} and p^s_{G2}in that state.

Period 3. In period $t = 3$, there are three possible states denoted by S_{31}, S_{32} and S_{33}. Each agent i enters period 3 holding θ_{iB2} shares of firm B and θ_{iG2} shares of firm G, possibly different for different states, following which the outputs of intermediate goods of firms B and G are realized and converted into final consumption goods that are paid out as dividends.

Firm G's dividend, D_{G3}, does not depend on the state, but firm B's dividend, D_{B3s}, does. When firm B does not adopt the green technology (either in state 1 – where the technology is not available – or state 2 – where it is available but not adopted), the dividend is $D_{B3} = D_{B31} = D_{B32}$. Not adopting the green technology has two consequences. First, firm B generates δD_{B3} units of public bad. Second, the government taxes firm B's output at the rate τ. The government redistributes the tax revenue uniformly to all agents. On the other hand, if the green technology is adopted (state S_{33}), firm B will produce $(1 - \eta) D_{B3}$ units of consumption goods, which will be paid out as dividends, without generating any public bad, and there is no tax. In each of the states S_{31}, S_{32} and S_{33}, agents choose consumption c_{iB3} and c_{iG3} given the price of brown consumption goods.

In summary, states S_{21} and S_{22} are determined by nature (availability of the green technology). States S_{22A} and S_{22N} (and the subsequent states at $t = 3$) are the outcomes of the actions by the agents and firm B's manager.

4.2 Optimization problem of individual agents

We now describe the optimization problems of individual agents in each period. Recall that an ESG agent is indexed by $i \in [0, k]$ and a $NESG$ agent is indexed by $i \in (k, 1]$.

Period 1. Under the Exit and Boycott strategies, both ESG and $NESG$ agents face the same problem at $t = 1$. Each agent $i \in [0, 1]$ takes prices as given and decides how much to consume and what portfolio to hold by maximizing

$$U_{i1} = \max_{\theta_{iB1}, \theta_{iG1}, c_{i1}} \left\{ -e^{-Ac_{i1}} + \mathbf{E}_1 \left[U_{i2} \left(\theta_{iB1}, \theta_{iG1} \right) \right] \right\}, \tag{4.1}$$

subject to the budget constraint

$$c_{i1} + \theta_{iB1} p^s_{B1} + \theta_{iG1} p^s_{G1} = \theta_{iB0} p^s_{B1} + \theta_{iG0} p^s_{G1} + \psi_{i1}$$

where U_{i2} is the period-2 utility of agent i, to be specified below. This may have different values for different activist strategies and different equilibrium paths. $\mathbf{E}_1$ is the expectation with respect to the availability of the green technology and the technology adoption rules to be specified in Section 4.3.2.

At $t = 1$, agents take into account uncertainty about the availability of green technology. Denote the share prices of firms B and G at $t = 1$ as p^s_{B1} and p^s_{G1}, respectively. The numeraire in this period is the consumption good, assumed to be from the green sources at $t = 1$ and 2.

Under the Voice strategy, ESG agents are subject to the additional constraint that $\theta_{iG1} = 0$ for $i \in [0, k]$.

Period 2. At $t = 2$, the green technology is not adopted in states S_{21} and S_{22N}, and adopted in state S_{22A}. The numeraire in this period is again the consumption good. Denote the share prices of firms B and G at $t = 2$ as p^s_{B2} and p^s_{G2}, respectively. Under the Boycott and Voice strategies, both ESG and $NESG$ agents face the same problem at $t = 2$. In each of the states S_{21}, S_{22N} and S_{22A}, each agent $i \in [0, 1]$ takes prices as given and decides how much to consume and what portfolio to hold by maximizing

$$U_{i2} \left(\theta_{iB1}, \theta_{iG1} \right) = \max_{\theta_{iB2}, \theta_{iG2}, c_{i2}} \left\{ -e^{-Ac_{i2}} + U_{i3} \left(\theta_{iB2}, \theta_{iG2} \right) \right\}, \tag{4.2}$$

subject to the budget constraint $c_{i2} + \theta_{iB2} p^s_{B2} + \theta_{iG2} p^s_{G2} = \theta_{iB1} p^s_{B2} + \theta_{iG1} p^s_{G2} + \psi_{i2}$, where U_{i3} is the period-3 utility of agent i to be specified below and may have different values for different activist strategies and different equilibrium paths.

Under Exit, $NESG$ agents continue to solve the above optimization problem, but ESG agents will be subject to an additional constraint: $\theta_{iB2} = 0$ for $i \in [0, k]$ in state S_{22N}.

Period 3. At $t = 3$, we use the consumption good produced by firm G as the numeraire. Denote p^c_{B3} as the pre-tax price of consumption good from firm B. Under the Exit and Voice strategies, both ESG and $NESG$ agents face the same problem at $t = 3$. In each of the states S_{31}, S_{32} and S_{33}, each agent $i \in [0, 1]$ chooses how much of firm G's and firm B's consumption good to consume so as to maximize the utility

$$U_{i3}\left(\theta_{iB2}, \theta_{iG2}\right) = \max_{c_{iB3}, c_{iG3}} \left\{ -e^{-A\left(c_{iB3}+c_{iG3}-\delta D_{B3}(1-\mathbf{1}_{(S_{33})})\right)} \right\} \tag{4.3}$$

subject to the budget constraint

$$\begin{aligned} & c_{iG3} + p^c_{B3}(1 + \tau(1 - \mathbf{1}_{(S_{33})}))c_{iB3} \\ = \quad & \theta_{iG2} D_{G3} + \theta_{iB2} p^c_{B3}(D_{B3} - \eta D_{B3} \mathbf{1}_{(S_{33})}) + \tau p^c_{B3}(1 - \mathbf{1}_{(S_{33})}) D_{B3}, \end{aligned}$$

where $\mathbf{1}_{(S_{33})}$ denotes the indicator function that takes the value of 1 if the state in period 3 is S_{33} and 0 otherwise. In the states where the green technology is not adopted, the budget constraint includes terms reflecting the negative externality, η, as well as the tax and tax rebate.

Under the Exit strategy in state S_{22N}, $\theta_{iB2} = 0$ for $i \in [0, k]$. Under Boycott, ESG agents will be subject to an additional constraint: $c_{iB3} = 0$ for $i \in [0, k]$ in state S_{32}.

Under the Exit and Voice strategies, the maximization problem in (4.3) is straightforward and can be reduced to maximizing the total quantity of consumption, $c_{iB3} + c_{iG3}$

To summarize, all $NESG$ agents solve standard portfolio-choice problems at each point in time, taking into account the uncertainty in the availability of the green technology at $t = 2$. Each ESG agent $i \in [0, k]$ is subject to an additional constraint $\theta_{iG1} = 0$ at $t = 1$ under Voice, $\theta_{iB2} = 0$ at $t = 2$ under Exit in state S_{22N}, and $c_{iB3} = 0$ at $t = 3$ under Boycott in state S_{32}.

4.3 Decision problem of firms

4.3.1 Firm G

Firm G in this economy produces the green output, and its manager makes no decisions regarding production or technology adoption.

4.3.2 Firm B

If the green technology is available (state S_{22}), the manager of firm B can adopt the technology at a cost of reducing output by the fraction η. Following adoption, firm B will not produce any public bad and agents in the economy will know that firm B adopted used the green technology.

The objective of firm B's existing manager, who is an $NESG$ manager, is to make the technology decision that maximizes the value of the shares at $t = 2$, which is a standard assumption in corporate finance.[26] Thus, the manager needs to compare firm B's value along the two possible equilibrium paths, adoption and no adoption, i.e., Paths 2 and 3 in Figure 1, adopting the green technology if and only if it results in a higher firm value. By contrast, an ESG manager is the one who always chooses to adopt the green technology in state S_{22}, even if the adoption leads to a drop in firm value. Firm B comes with the default $NESG$ manager, and shareholders can vote to replace the $NESG$ manager with an ESG manager by a proxy vote at $t = 1$ under the Voice strategy.

The state of the economy when the green technology is available, but prior to the adoption decision, is S_{22}. The firm B manager will select state S_{22A} (adoption) or S_{22N} (no adoption). dependingon which state will have a higher brown share price. Therefore, we write state S_{22} as a function of the manager's decision rule as follows. If there is an $NESG$ manager, the adoption rule depends on the stock price conditional on adoption:

$$S_{22} \longrightarrow \begin{cases} S_{22A} \text{ if } & p^s_{B2}\left(S_{22A}\right) > p^s_{B2}\left(S_{22N}\right) \\ S_{22N} \text{ if } & p^s_{B2}\left(S_{22A}\right) \leq p^s_{B2}\left(S_{22N}\right) \end{cases}. \tag{4.4}$$

[26] We have assumed the firms are large enough so that manager's decision will affect share prices, but the manager will not deliberately manipulate prices. We leave the study of infinitesimal firms for future research.

With an ESG manager, by contrast, the technology is always adopted, so the state is S_{22A}. We will use indicator functions $\mathbf{1}_{\left(p^s_{B2}(S_{22A})>p^s_{B2}(S_{22N})\right)}$ and $\mathbf{1}_{\left(p^s_{B2}(S_{22A})\leq p^s_{B2}(S_{22N})\right)}$ to denote the states defined in expression 4.4.

In the next section, we characterize the equilibrium in our economy when the ESG agents follow one of the three strategies: Exit, Boycott and Voice. Proofs of the propositions that appear in the next section are given in Appendix A.

5 Equilibrium

In this section, we define equilibrium and present numerical solutions of the model. We first discuss the benchmark economy with an emissions tax. Unsurprisingly, imposing a sufficiently high emissions tax can induce the brown firm manager to adopt the green technology. In practice, such taxes have been unpopular, so we allow ESG agents to follow one of the three strategies: Exit, Boycott, and Voice. Throughout this section, we assume homogeneous endowments among each group of agents (ESG and $NESG$) but allow heterogeneity between ESG and $NESG$ agents, and we also allow firms G and B to be of different sizes.

In Section 5.1, we define the benchmark equilibrium in which there is an emissions tax and in which ESG agents do not engage in activist strategies.[27] In Section 5.2, we examine the equilibrium when all agents have identical endowments of shares and consumption goods, while in Section 6.1 we examine the equilibrium when ESG and $NESG$ agents differ in their endowments but are identical within their group. In Section 6.2, we allow heterogeneous firm sizes. In Sections 5.2–6.2, we characterize the equilibrium under Exit, Boycott, and Voice.

5.1 Definition of benchmark equilibrium

Definition 5.1. In the benchmark equilibrium:

- ESG agents do not undertake activist strategies
- $\tau < \overline{\tau} \equiv \frac{e^{A(\delta-\eta)D_{B3}}}{1-\eta} - 1$, (firm B does not convert to green technology; Proposition 5.1, below)

[27] We characterize equilibrium with non-activist ESG agents in order to introduce the relevant notation.

- a set of the consumption and portfolio holdings given by $(c_{it}, \theta_{iBt}, \theta_{iGt})$ for each agent $i \in [0,1]$ in periods $t = 1$, 2, and with period 3 consumption given by (c_{iB3}, c_{iG3}).
- a technology adoption decision rule given in (4.4);
- prices of shares of firms B and G in periods 1 and 2, and price of the consumption good produced by firm B in period 3 given by the price vector $\left(p^s_{B1}, p^s_{G1}, p^s_{B2}, p^s_{G2}, p^c_{B3}\right)$;

such that

(i) given the price vector and the technology adoption rule, the consumption and portfolio holdings in each period solve the maximization problems given in equations (4.1), (4.2), and (4.3);

(ii) the markets for consumption goods and shares clear given the consumption and portfolio holdings at $t = 1, 2$, consumption at $t = 3$, and the price vector. The market clearing conditions are given by: $\int_i c_{i1} di = \int_i \psi_{i1} di = \psi_1$, $\int_i c_{i2} di = \int_i \psi_{i2} di = \psi_2$, $\int_i c_{iG3} di = D_{G3}$ and $\int_i c_{iB3} di = D_{B3} - \eta D_{B3} \mathbf{1}_{(S_{33})}$ for the consumption goods market, and $\int_i \theta_{iB1} di = \int_i \theta_{iG1} di = 1$ and $\int_i \theta_{iB2} di = \int_i \theta_{iG2} di = 1$ for the shares market.

Proposition 5.1. *In the Benchmark equilibrium, the green technology is not adopted by the value maximizing manager if $\tau < \overline{\tau}$, where*

$$\overline{\tau} = \frac{e^{A(\delta-\eta)D_{B3}}}{1-\eta} - 1. \tag{5.1}$$

Most of our derivations will be in Appendix A, but we describe here the proof of Proposition 5.1 to illustrate the workings of the model. The question is whether the manager of the brown firm will adopt the green technology. This decision is only relevant in State S_{22}, in which the technology exists, and has an effect only in period 3, in which production occurs and the tax is levied on output if the technology is not adopted. The manager decides by comparing share prices in States S_{22N} (non-adoption) and S_{22A} (adoption), and takes the action that maximizes the share price.[28] Standard calculations, detailed in Appendix A,

[28]Note that in making the decision, the manager is comparing two equilibria and affecting the discount factor. This is the reason that even if $\eta = 0$, $\bar{\tau} > 0$.

show that the discount factors in the two states are

$$M_A\left(c_{i2}, D_{G3} + D_{B3}(1-\eta)\right) = e^{Ac_{i2} - A(D_{G3} + D_{B3}(1-\eta))} \tag{5.2}$$

$$M_N\left(c_{i2}, D_{G3} + D_{B3}(1-\delta)\right) = e^{Ac_{i2} - A(D_{G3} + D_{B3}(1-\delta))}. \tag{5.3}$$

If there is adoption, period 2 consumption is unaffected but period 3 consumption is reduced by the fraction η. If there is no adoption, aggregate consumption is reduced by the externality, δD_{B3}. Shares provide a claim to period 3 output. Agents will pay the same price for output from both firms, so when the technology is not adopted, the price of the brown output must be reduced by the factor $1/(1+\tau)$, so that the post tax price equals that of the green good. The price of the brown shares in the two states is the discount factor times the cash flow in that state. Thus, the ratio of equilibrium share prices is

$$\begin{aligned}\frac{p^s_{B2}\left(S_{22N}\right)}{p^s_{B2}\left(S_{22A}\right)} &= \frac{M_N\left(\psi_2, D_{G3} + D_{B3}\right)\frac{D_{B3}}{1+\tau}}{M_A\left(\psi_2, D_{G3} + D_{B3}\left(1-\eta\right)\right) D_{B3}\left(1-\eta\right)} \\ &= \frac{e^{A(\delta-\eta)D_{B3}}}{\left(1-\eta\right)\left(1+\tau\right)}.\end{aligned}$$

This expression is less than 1 (tax-induced adoption is optimal) when $\tau > \overline{\tau}$, as defined in equation (5.1) in Proposition 5.1. Thus, Proposition 5.1 defines the tax rate at which the brown firm is incentivized to adopt the green technology. Carbon taxes are frequently discussed but infrequently enacted, consistent with the observation of Golosov et al. (2014) and Nordhaus (2019) that tax rates in practice are often lower than optimal due to institutional restrictions. Thus, we will retain the tax in the model but focus on the role of activists. In particular, we assume $\tau < \overline{\tau}$ for the rest of the paper.

Finally, going forward we define the interest rate to be the return on the green share, which is a claim to the green consumption good at $t = 3$. Note that in the benchmark equilibrium all agents are identical and there are no activists, so in order for markets to clear the return on brown and green firm shares must be the same.

In the following, we see how the economy changes with activism undertaken by ESG agents, those with $i \in [0, k]$. Agents of a given type (ESG or $NESG$) are identical and we assume that, in equilibrium, they make the same consumption, investment, and activism decisions. Hence, instead the subscript of i, we use superscripts esg and $nesg$ to distinguish the types. For example, we use c_1^{esg} for c_{i1} with $i \in [0, k]$. We further normalize the initial supply of shares to be one for each firm.

5.2 Equilibrium with activist agents

We will illustrate equilibrium under each activist strategy with numerical examples using parameters defined in Table 1. We choose these parameters so that in the equilibrium with $k = 0$ (no ESG agents), the net returns on both brown and green shares are zero. We set $\delta > \eta$ as in expression (3.2).

5.2.1 Equilibrium under Exit

In the Exit strategy, ESG agents sell brown shares in period 2 if the green technology exists and is not adopted (state S_{22N}). If the technology is adopted or does not exist they take no action. Existence of the green technology is the only uncertainty, and the conditional strategy of the ESG shareholders in period 2 is rationally anticipated in period 1.[29] ESG agents will hold no brown shares in state S_{22N}:

$$\theta_{B2}^{esg}(S_{22N}) = 0. \tag{5.4}$$

We are interested in the effect of the exit strategy on both shares and goods prices,

Proposition 5.2. *In an Exit equilibrium there are thresholds $\bar{k}_{exit}$ and $\bar{\bar{k}}_{exit}$ such that*

- *if $k < \bar{k}_{exit}$, share prices will be the same as in the Benchmark equilibrium, and the green technology will not be adopted when it is available.*
- *if $\bar{k}_{exit} < k \leq \bar{\bar{k}}_{exit}$, shares prices will deviate from prices in the Benchmark equilibrium, and the green technology will not be adopted in a pure strategy equilibrium when it is available.*[30]

[29] By assumption, activist strategies are only present when the green technology is available but not adopted, which means that ESG agents do not have preferences for green in states S_{21} or S_{22A}.

[30] There can be mixed strategies of adoption in this region and within a small neighborhood of $\bar{\bar{k}}_{exit}$. See Table IA.3 for numerical examples.

- *if* $k > \bar{\bar{k}}_{exit}$, *the green technology, if available, will be adopted in a pure strategy equilibrium.*

- *the price of the green good is 1 (it is numeraire); the price of the brown good in different states is* $p^c_{B3}(S_{31}) = p^c_{B3}(S_{32}) = \frac{1}{1+\tau}$ *and* $p^c_{B3}(S_{33}) = 1$.

When following the Exit strategy, ESG agents do not distinguish green and brown goods. Therefore the cum-tax price of the brown good must equal that of the (untaxed) green good. Thus, we have $p^c_{B3}(S_{31}) = p^c_{B3}(S_{32}) = \frac{1}{1+\tau}$ and $p^c_{B3}(S_{33}) = 1$.

The mechanism in the case of Exit is straightforward, although the results require some explanation. The basic idea is that in period 1, ESG agents sell all their brown shares in exchange for green shares. $NESG$ agents are the counterparty. The behavior of ESG agents is mechanical, but $NESG$ agents are willing holders of both brown and green shares, and the shares must be priced accordingly.

The Exit strategy can work only if the fraction of ESG agents is large enough for divestment to affect the brown stock price significantly. "Significant" in this case means that divestment must drive the brown stock price so low that the share price gain from adopting the green technology outweighs the cost of adoption. From this verbal description, it's clear there will are potentially three regions: no price effect for low k; a price effect insufficient to induce adoption for intermediate k; and adoption for large k. Figure 2 illustrates brown and green share prices, as a function of k, at time 1 and in state S_{22}. We will now explain that figure and how we determine the cutoffs $\bar{k}$ and $\bar{\bar{k}}$. Panel (a) in Figure 2 corresponds to $t = 1$ and panel (b) corresponds to $t = 2$ when the green technology is available, i.e., state S_{22}. There are two critical thresholds for k, $\bar{k}_{\text{exit}} = 0.524$ and $\bar{\bar{k}}_{\text{exit}} = 0.577$.

Example 1. Using the parameters in Table 1, we characterize the Exit equilibrium.[31] Figure 2 plots the prices of brown and green shares against k, the fraction of ESG agents.

[31] In Section IA.4, we demonstrate that for a small region of k, there could be multiple pure strategies. When this occurs, we pick the non-adoption equilibrium for Example 1. Furthermore, there may exist mixed strategy equilibria. A detailed discussion of multiple pure and mixed strategy equilibria is given in Section IA.4, and the existence of a mixed strategy equilibrium can be found in Appendix IA.1.1.

Small k: $k \leq \bar{k}$

We define $\bar{k}$ as the largest value of k for which the economy is unaffected by ESG agents selling all their brown shares. For the values in Table 1, $\bar{k} = 0.524$. To understand how $\bar{k}$ is determined, note that when $k \leq \bar{k}$, adoption will not occur, regardless of whether or not the technology exists. In this case brown and green shares are priced so that agents are indifferent about which they hold, and the price of each is the present value of dividends that share will receive. Thus the price of the green shares is $p^s_{G1} = 0.570$ (the value to be paid in period 3), while the price of the brown shares is $p^s_{B1} = \frac{p^s_{G1}}{1+\tau} = 0.518$.[32] Below $\bar{k}$, prices of both the brown and green shares are constant and identical in period 1 and state S_{22}.[33] These results are plotted in Figure 2.

To understand how $\bar{k}$ is determined, all agents have equal endowments of green and brown shares at $t = 1$, and the two shares must have the same return when $NESG$ agents willingly hold brown and green shares. We may thus assume that all agents arrive at state S_{22N} holding their endowed shares. When the stock market opens at the beginning of $t = 2$ and the technology exists, ESG agents will divest brown shares. Therefore $NESG$ agents in aggregate will exchange $1 - \bar{k}$ green shares for $\bar{k}$ brown shares from the ESG agents. For $NESG$ agents to make this trade, the value of brown shares divested by ESG agents must be equal to the value of green shares sold by $NESG$ agents. That is, $\bar{k}p^s_{B2}(S_{22N}) = (1 - \bar{k})p^s_{G2}(S_{22N})$. Solving, we obtain $\bar{k} = 0.5238$. This (and other results) obviously rely on the absence of cash flow risks. By way of comparison, Heinkel et al. (2001) have cash flow risks, so even with few activist investors, prices are affected by divestment. However, if the cash flows from brown and green firms are highly correlated, then the risk is analogous to a systematic risk, and we would also expect no price effect in their model when the number of activists is sufficiently small.

[32] We selected parameters so that the expected return is zero when the technology is not adopted. Thus, when adoption will not occur, the present value of the period 3 dividend is just the amount of the dividend that will be paid.

[33] $NESG$ agents will be indifferent because they are not activists, and therefore prices must be such that they are willing to trade and to hold both kinds of shares.

Intermediate k: $\bar{k} < k < \bar{\bar{k}}$

In this region, where $\bar{\bar{k}} = 0.577$, the aggregate wealth of ESG agents is sufficient to buy all green shares. As a result, if k is greater, the price of green shares is higher (more agents purchase the existing stock of green shares) and the price of brown shares (purchased by fewer agents) is lower. In this region, however, the brown price is not low enough for the price benefit of adoption (more agents willing to hold brown shares) to overcome the cost of adoption (reduced output).[34] The effect of k on share prices is apparent in Figure 2.

Large k: $k \geq \bar{\bar{k}}$

In this region the Exit strategy is successful: the brown firm adopts the green technology. Output declines from 1 to $1 - \eta$, but the emissions tax is not levied. The net result is that the brown share price declines by more than the green share price relative to the Benchmark equilibrium.

Figure 2 highlights the response of shares prices to an unexpected increase in activists. Suppose the fraction of activists changes from $\bar{\bar{k}} - \varepsilon$ to $\bar{\bar{k}} + \varepsilon$. The economy then transitions from no adoption to adoption if the green technology is available. In the example, we observe that green share price falls from 0.604 to 0.553 while the brown share price remains almost unchanged. This is an example where the technology exists and is adopted but green shares are riskier than brown shares.

The threshold $\bar{\bar{k}}$ is determined by the brown firm manager's comparison of the brown firm share price if the technology is adopted ($p^s_{B2}(S_{22A})$) or is not adopted ($p^s_{B2}(S_{22N})$); $\bar{\bar{k}}$ is the smallest k at which the technology is adopted if it exists. The calculation of $\bar{\bar{k}}$ is complicated because it takes into account optimizing decisions in all three periods. To understand the calculation, agents know in period 1 if $k > \bar{\bar{k}}$. If so, adoption of the technology depends only on its existence. Uncertainty about existence creates risk that affects agents' period 1 share holdings. Once in period 2, whether the technology exists affects wealth and thus affects the realized marginal rate of substitution between period 2 and 3; this in turn affects the valuation of shares in period 2. Because of the complexity of this calculation we solve

[34] When A is large (e.g. $A = 7$), there will be only mixed strategy equilibria when $k < \bar{\bar{k}}$ but sufficiently greater than $\bar{k}$. Nevertheless, the results are otherwise qualitatively similar to those in this section.

numerically for $\bar{\bar{k}}$.[35] Note that when $k \geq \bar{\bar{k}}$ the share price associated with non-adoption will be off-equilibrium and that price will never be observed by agents.

To explain the computation in this and other cases, we briefly sketch the calculations that determine adoption if the technology exists. When the green technology is not adopted, ESG and $NESG$ agents hold the entire green and brown firm, respectively: $\theta_{G2}^{esg}(S_{22N}) = \frac{1}{k}$ and $\theta_{B2}^{nesg}(S_{22N}) = \frac{1}{1-k}$. With a uniform tax rebate $\frac{\tau}{1+\tau}D_{B3}$, the period 3 consumption of each agent is

$$c_3^{nesg}(S_{32}) = \frac{1}{1-k}\frac{1}{1+\tau}D_{B3} + \frac{\tau}{1+\tau}D_{B3} \tag{5.5}$$

$$c_3^{esg}(S_{32}) = \frac{1}{k}D_{G3} + \frac{\tau}{1+\tau}D_{B3} \tag{5.6}$$

The market clearing condition for consumption goods in state S_{22N} is

$$kc_2^{esg}(S_{22N}) + (1-k)c_2^{nesg}(S_{22N}) = k\psi_2^{esg} + (1-k)\psi_2^{nesg}. \tag{5.7}$$

The budget constraints at $t = 2$ depend upon investments in period 1. For example, given θ_{B1}^{nesg} and θ_{G1}^{nesg}, the budget constraint for a $NESG$ agent in state S_{22N} is

$$c_2^{nesg}(S_{22N}) + \frac{1}{1-k}p_{B2}^s(S_{22N}) = \theta_{B1}^{nesg}p_{B2}^s(S_{22N}) + \theta_{G1}^{nesg}p_{G2}^s(S_{22N}) + \psi_2^{nesg}. \tag{5.8}$$

Given consumption in periods 2 and 3, we can compute share prices in period 2 in the different states:

$$p_{G2}^s(S_{22N}) = e^{Ac_2^{esg}(S_{22N}) - A\left(c_3^{esg}(S_{32}) - \delta D_{B3}\right)}D_{G3}. \tag{5.9}$$

$$p_{B2}^s(S_{22N}) = e^{Ac_2^{nesg}(S_{22N}) - A\left(c_3^{nesg}(S_{32}) - \delta D_{B3}\right)}\frac{1}{1+\tau}D_{B3}. \tag{5.10}$$

If the green technology is adopted, the brown share price $p_{B2}^s(S_{22A})$ can be computed in

[35] Notice that unlike state S_{22A} where the shareholdings are indeterminate because both shares have the same return and there is no output risk, the shareholdings at $t = 1$ will be exactly pinned down by the above intertemporal optimizations even if state S_{22A} will be reached in equilibrium. This is because agents must take into account different share prices in states S_{21} and S_{22A} when choosing portfolios at $t = 1$.

a similar way as in the Benchmark equilibrium, and it satisfies

$$p^s_{B2}(S_{22A}) = e^{A\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}\right)-A(D_{G3}+(1-\eta)D_{B3})}(1-\eta)D_{B3}. \tag{5.11}$$

In the first period, ESG agents do not have a preference for green. Both types of agents will hold the brown shares, which implies that all agents must agree on the green and brown share prices at $t = 1$. From intertemporal optimizations, the period-1 green share price satisfies both

$$p^s_{G1}e^{-Ac_1^{esg}} = pe^{-Ac_2^{esg}(S_{22})}p^s_{G2}\left(S_{22}\right) + (1-p)\,e^{-Ac_2^{esg}(S_{21})}p^s_{G2}\left(S_{21}\right) \tag{5.12}$$

$$p^s_{G1}e^{-Ac_1^{nesg}} = pe^{-Ac_2^{nesg}(S_{22})}p^s_{G2}\left(S_{22}\right) + (1-p)\,e^{-Ac_2^{nesg}(S_{21})}p^s_{G2}\left(S_{21}\right) \tag{5.13}$$

from $NESG$ agents' perspective, where $p^s_{G2}\left(S_{22}\right)$ is the equilibrium green share price when the green technology is available. The equilibrium pricing equations for the brown share can be derived similarly as follows

$$p^s_{B1}e^{-Ac_1^{esg}} = pe^{-Ac_2^{esg}(S_{22})}p^s_{B2}\left(S_{22}\right) + (1-p)\,e^{-Ac_2^{esg}(S_{21})}p^s_{B2}\left(S_{21}\right) \tag{5.14}$$

$$p^s_{B1}e^{-Ac_1^{nesg}} = pe^{-Ac_2^{nesg}(S_{22})}p^s_{B2}\left(S_{22}\right) + (1-p)\,e^{-Ac_2^{nesg}(S_{21})}p^s_{B2}\left(S_{21}\right). \tag{5.15}$$

We obtain the equilibrium shareholdings at $t = 1$ by taking into account that the share prices at $t = 2$ depend on the period-1 shareholdings, together with period-1 budget constraint for ESG agents

$$p^s_{B1}\theta^{esg}_{B1} + p^s_{G1}\theta^{esg}_{G1} + c_1^{esg} = p^s_{B1}\theta^{esg}_{B0} + p^s_{G1}\theta^{esg}_{G0} + \psi_1^{esg} \tag{5.16}$$

and the market clearing condition for consumption good

$$kc_1^{esg} + (1-k)c_1^{nesg} = k\psi_1^{esg} + (1-k)\psi_1^{nesg}. \tag{5.17}$$

The adoption threshold $k = \bar{\bar{k}}$ is defined such that $p^s_{B2}(S_{22N}) = p^s_{B2}(S_{22A})$. Together with (5.9) and (5.10) as well as (5.5)–(5.17), we obtain a system of equations in $k = \bar{\bar{k}}$. We use this numerical example to illustrate the calculation of $\bar{\bar{k}}$. The proof of the existence and uniqueness of $\bar{\bar{k}}$ can be found in Appendix A.1.

Figure 3 shows the ratio of brown share price to green share price. The relative share price stays at $\frac{1}{1+\tau} = 0.909$ when $k \leq \bar{k}$. For$\bar{k} < k < \bar{\bar{k}}$, the price ratio decreases until the point $\bar{\bar{k}}$ where the green technology is adopted. The ratio is constant at $1 - \eta = 0.85$ in state S_{22A}, after adoption; the brown firm is green, but produces less output after adoption.

Figure 4 shows the utilities of both types of agents at $t = 1$. When $k \leq \bar{k}$, the utilities are the same across all agents because the equilibrium is identical to the Benchmark equilibrium. When $\bar{k} < k \leq \bar{\bar{k}}$, the ESG agents' preferences for green will incur a utility cost as they buy the more expensive green shares and sell the cheaper brown shares. $NESG$ agents benefit from this behavior.[36] Since $NESG$ agents are indifferent, they can purchase the cheaper brown shares and have greater utility. Once the green technology is adopted ($k > \bar{\bar{k}}$), firm B is essentially green. The equilibrium becomes the Benchmark equilibrium with lower brown firm's output and no public bad. As a result, the utilities of both types of agents are identical.

Table 2 provides equilibrium and off-equilibrium values of holdings, share prices, returns, consumption allocations and utilities for three values of k:$k = 0.3 < \bar{k}$; $\bar{k} < k = 0.54 < \bar{\bar{k}}$; and $\bar{\bar{k}} < k = 0.65$. The table reports off-equilibrium share prices; when $k = 0.65$, the off-equilibrium brown share price, 0.374, is lower than the (equilibrium) adoption price, 0.464. The manager therefore chooses to adopt.

5.2.2 Equilibrium under Boycott

Next, we consider a case where ESG agents follow the Boycott strategy, which is a boycott of brown firm consumption goods in state S_{32} when the technology was available but not adopted:

$$c_{B3}^{esg}\left(S_{32}\right) = 0. \tag{5.18}$$

In a Boycott equilibrium, the fraction of ESG agents is crucial for the adoption of the green technology as in an Exit equilibrium. Since ESG agents treat the two types of

[36]In equilibrium, $NESG$ cannot have lower utilities than ESG agents because they can always mimic the behaviors of ESG agents.

consumption goods differently, the pre-tax price of brown consumption goods in units of green goods will not necessarily be $\frac{1}{1+\tau}$ in state S_{32}.

Proposition 5.3. *There are thresholds $\bar{k}_{boycott}$ and $\bar{\bar{k}}_{boycott}$ such that when $k \leq \bar{k}_{boycott}$, share prices in a Boycott equilibrium will be the same as share prices in the Benchmark equilibrium, and the green technology is never adopted. When $k < \bar{\bar{k}}_{boycott}$, the green technology will be adopted if available.*

The intuition for this proposition is similar to that in Proposition 5.2. It is natural to compare the adoption threshold levels of k under the Exit and Boycott strategies, which is given in the following proposition.

Proposition 5.4. *In any state where the brown firm manager adopts the green technology under Exit equilibrium, the green technology is also adopted under Boycott equilibrium. However, the converse does not hold.*

First, if there is no taxation, the two mechanisms have equivalent effectiveness. In the Boycott equilibrium, if the brown firm manager does not adopt the green technology, ESG agents allocate all of their wealth to the green consumption goods. For the Boycott strategy to make a difference in the economy, there has to be a large enough difference in the prices of the green and brown goods. This requires that the ESG agents consume all of the green output, which drives up its price.. Similarly, under Exit, the ESG agents allocate 100% of their savings to the shares and output of the green firm. Exit and Boycott are equivalent when there are no taxes but differ when brown output is taxed. The tax widens the wedge between green and brown output prices, affects the share prices similarly and enables boycott to succeed at a lower k. As a result, the period-three consumption by an individual $NESG$ agent when there is a price effect ($k > \bar{k}$) is $c_3^{nesg}(exit) = \left(\frac{1}{1-k}\frac{1}{1+\tau} + \frac{\tau}{1+\tau}\right) D_{B3}$ under Exit and $c_3^{nesg}(boycott) = \frac{1}{1-k} D_{B3}$ under Boycott. The first term in $c_3^{nesg}(exit)$ is due to each $NESG$ agent holding of $\frac{1}{1-k}$ shares of the brown firm and the second term is due to the uniform tax rebate. It is easy to see that $c_3^{nesg}(exit) < c_3^{nesg}(boycott)$, so we should expect a higher brown share price under Exit than under Boycott, leading to Boycott being a more effective strategy. Indeed, Lemma A.10 in the Internet Appendix shows such comparison.

Example 2. We assume the same set of parameters as in Example 1. Again, the two firms have equal size for the purpose of exposition. The features and intuition of the Boycott equilibrium are similar to the Exit equilibrium discussed earlier except for one crucial difference as follows. We observe that both of the thresholds $\bar{k} = 0.5$ and $\bar{\bar{k}} = 0.553$ in the Boycott equilibrium are lower than their counterparts in the Exit equilibrium as mentioned in Proposition 5.4. This implies that holding everything else equal, the Boycott strategy is more effective than Exit in terms of requiring a lower fraction of ESG agents to be present for technology adoption. See Internet Appendix IA.3.1 for further discussions.

5.2.3 Equilibrium under Voice

Finally, we consider Voice. Consider a scenario in which ESG agents hold only the shares of the brown firm (and divest from investing in the green firm) at $t = 1$. When the aggregate share of ESG agents is more than half of the outstanding shares of the brown firm, the ESG agents can replace the incumbent manager of the brown firm with an ESG manager who adopts the green technology if available, i.e.,

$$\theta_{G1}^{esg} = 0 \text{ and } S_{22} = S_{22A} \text{ if } k\theta_{B1}^{esg} > 0.5. \tag{5.19}$$

We examine the equilibrium when ESG agents behave in this manner as given in (5.19). As in an Exit or Boycott equilibrium, a sufficiently large ESG population is necessary to make any difference in a Voice equilibrium.

Proposition 5.5. *In a Voice equilibrium, there is a threshold $\bar{\bar{k}}_{voice}$ such that the green technology is adopted if $k > \bar{\bar{k}}_{voice}$.. There is another threshold $\hat{k}_{voice} > \bar{\bar{k}}_{voice}$, beyond which only ESG agents hold the brown shares after trading at $t = 1$.*

With Voice, $\bar{k}_{\text{voice}} \equiv \bar{\bar{k}}_{\text{voice}}$. We can compare the thresholds of k such that the green technology is adopted under Boycott and Voice. We have already shown that for a given fraction of ESG agents in the population, if the green technology is adopted under Boycott, it will also be adopted in the Exit equilibrium.

Proposition 5.6. *With homogeneous endowments across agents, $k > \frac{D_{G3}}{D_{B3}+D_{G3}}$ is necessary for the green technology to be adopted in Exit and Boycott equilibria. In a Voice equilibrium, the green technology will be adopted if $k > \frac{1}{2} \cdot \frac{D_{B3}(1-\tau)}{D_{G3}+D_{B3}(1-\tau)}$ when it becomes available.*

Proposition 5.6 implies that when $D_{B3} = D_{G3}$, $k > \frac{1}{2}$ is a necessary condition for the green technology to be adopted in Exit and Boycott equilibria, and $k > \frac{1}{2} \cdot \frac{1-\tau}{2-\tau}$ is a sufficient condition for the green technology to be adopted in a Voice equilibrium. If the brown firm is larger than the green firm, the Boycott strategy easily becomes effective by boosting the price of green consumption good. By contrast, when the green firm is larger than the brown firm, the *ESG* agents can easily hold the majority of the brown firm shares through the Voice strategy. When the firms are of the same size, adoption of the green technology requires fewer *ESG* agents in the population under the Voice strategy.

When the firms are equal-sized ($D_{B3} = D_{G3}$), in an Exit equilibrium the *ESG* agents have to hold 100% of the green firm's shares to affect brown share prices. In a Voice equilibrium, it is sufficient for *ESG* agents to hold just more than 50% of the brown firm shares for the green technology to be adopted. Furthermore, note that the condition $k > \frac{D_{G3}}{D_{B3}+D_{G3}}$ is *necessary* for the green technology to be adopted in an Exit or Boycott equilibria. In fact, this condition just guarantees that the Exit (5.4) or Boycott (5.18) makes the equilibrium different from the Benchmark equilibrium (Section 5.1). However, we find that k needs to be sufficiently larger than $\frac{D_{G3}}{D_{B3}+D_{G3}}$ to make $p^s_{B2}(S_{22A}) > p^s_{B2}(S_{22N})$ so that the brown firm manager adopts the green technology.

So far, we have shown that with equal firm size, fewer *ESG* agents are needed for the adoption of the green technology under Voice than under Exit or Boycott. However, from the perspective of *ESG* agents, Voice can be costly, especially when the fraction of *ESG* agents in the economy is very large. Note that when the fraction of *ESG* agents is sufficiently large (e.g., $k > \hat{k}$), the green technology, if available, is adopted in under Exit, Boycott as well as Voice. Under Exit or Boycott, the *ESG* agents do not have to exit or boycott in equilibrium. Hence, the *ESG* agents do not incur any cost. By contrast, under Voice, the *ESG* agents will boost the brown firm share price at $t = 1$ since they will be holding 100% of the brown firm shares and therefore suffer from the buying brown shares at a high price.

Example 3. In this example, we assume the same set of parameters as in the previous examples, where the two firms still have the same size. We defer the discussion of unequal firm sizes to Section 6.2. We also provide equilibrium values for three different values of k in the Internet Appendix IA.3.2.

Figure 5 plots the share prices at $t = 1$ and in state S_{22} when the green technology is available. The ESG manager for the brown firm is elected when the ESG agents hold more than 50% of the brown firm's shares, i.e., $k > \bar{\bar{k}}$. As shown in Proposition 5.6, when firm sizes are equal, the Voice strategy requires the least fraction of ESG agents to have the green technology adopted once available. In the example, we see that the threshold is 0.238, much lower than the one under Exit or Boycott.

More interesting is the behavior of share prices at $t = 1$ when the ESG agents own all of the brown firm's shares ($k > \hat{k}$). By assumption, every agent has the same endowments of shares prior to trading at $t = 1$. As k increases, the ESG agents in aggregate will offload more endowed green shares in order to purchase the brown shares. This will create a downward pressure on the green share price while boosting the brown share price.[37] Furthermore, to incentivize the $NESG$ agents who are indifferent toward holding brown or green shares to hold only the green shares, the return on the green shares must be high enough. The binding short-selling constraint ensures the share prices do not converge.

It is also worth mentioning that even though the share prices in states S_{21} and S_{22A} are constant in k when $k > \hat{k}$, the consumption (at $t = 1$ and in states S_{21} and S_{22A}) is not. This is in contrast to the Examples 1 and 2 that agents just consume their endowments when the green technology is adopted. The reason is that under either Exit or Boycott, the ESG agents can choose to exit or boycott conditional on the brown firm manager's decision. The manager, knowing how prices will behave as a function of the decision to adopt the green technology, takes the decision that maximizes firm value. Therefore, if the technology is adopted when available, in equilibrium the Exit or Boycott strategy will never show up. However, in a Voice equilibrium, the ESG agent must *a priori* sell off all of their green

[37] When k approaches 1, the brown share price at $t = 1$ starts to decrease for the following reasons. All agents start with equal wealth, and as k increases, the green share price becomes low and brown share price becomes high. Since the ESG agents need to sell all of their holdings of green shares and purchase only the brown shares, the per capita consumption at $t = 1$ will be lowered when k is sufficiently high. This will increase their marginal utilities at $t = 1$, and their intertemporal optimization will imply a lower brown share price.

shares and purchase only the brown shares before voting for the ESG manager. This means that when $k > \hat{k}$, the shares earn different returns from period 1 to period 2, which in turn implies that the consumption will deviate from the endowments at $t = 1$.

Figure 6 plots the utilities at $t = 1$. When $k \leq \hat{k}$, agents have the same utility, although the utility is slightly higher when $k \in [\bar{\bar{k}}, \hat{k}]$ due to the removal of public bad. When ESG agents are the only shareholders of the brown firm, the utility of the ESG ($NESG$) agents become lower (higher). This is because the ESG agents have to bear the high cost of and low returns on brown shares when k is large. The $NESG$ agents, on the other hand, enjoy both the benefits of high returns on green shares and no public bad, leading to higher utilities. This illustrates that even though Voice appears to be the most effective strategy, it can be very costly to ESG agents when the technology is adopted.[38] By contrast, when the technology is adopted under either Exit or Boycott, ESG and $NESG$ agents have identical utilities.

5.2.4 Summary of equilibria under various strategies

From the previous analyses and numerical illustrations, we observe that the fraction of ESG agents is crucial for determining share prices and green technology adoption (4.4) under the Exit (5.4), Boycott (5.18), and Voice (5.19) strategies. The intuition in general is that when there are too few ESG agents in the economy, their actions will not cause any material impact on equilibrium prices. Thus, the strategy will result in the same equilibrium as the Benchmark equilibrium. When there are a sufficient number of ESG agents and their aggregate wealth is large enough to buy out all of the green shares (Exit) or green consumption goods (Boycott), or own the majority shares of brown firm (Voice), their actions will be reflected in equilibrium prices. In the Voice strategy, this means that the ESG manager will be elected and the green technology is adopted. For Exit and Boycott, however, it does not mean the green technology will be automatically adopted. The default brown firm manager compares share prices and acts according to the technology rule (4.4). Only when the number of ESG agents is high enough ($k > \bar{\bar{k}}_{exit}$ or $\bar{\bar{k}}_{boycott}$), which causes a large

[38] If we allow ESG agents to coordinate with each other, then even if their population is above $\hat{k}$, they will only hold the majority but not all of the brown firm's shares in order to avoid the cost of holding all brown shares.

enough equilibrium price impact, will the green technology be adopted. We summarize the threshold levels of k under different strategies in Table 3.

Finally, we examine how the resolution of technological uncertainty affects share prices. Figure 7 shows the difference between the period-2 prices when the availability of the green technology is revealed and the period-1 price when the technology is uncertain. We observe that when k is up to the first threshold ($\bar{k}$ for Exit and Boycott and $\bar{\bar{k}}$ for Voice) there is no price impact because the share prices in this case are identical to those in the Benchmark equilibrium. If k is beyond the first threshold but less than the second one ($\bar{\bar{k}}$ for Exit and Boycott and $\hat{k}$ for Voice), under Exit and Boycott, green (brown) share price increases (decreases) when the green technology is available and vice versa. This is because Exit and Boycott strategies alter the prices in this region, as discussed earlier. Under Voice, the green share price decreases upon the arrival of the green technology since the technology will be adopted in this region and agents treat both types of shares in the same way. Thus, the larger "supply" of green shares makes the price lower. For firm B's shares, the price decrease in state S_{22} is mainly due to the reduced output.

When k is above the second threshold, under Exit and Boycott, both green and brown share prices decrease when the green technology is available and vice versa for the same reason as discussed for the middle region under Voice. The price impact under Voice when $k > \hat{k}$ is due to the low (high) period-1 green (brown) share price as ESG agents hold all of the brown shares at $t = 1$.

6 Heterogeneous Endowments and Firm Sizes

6.1 Heterogeneous endowments

In this section, we assume that ESG and $NESG$ agents have different endowments. However, all agents of a given type have the same endowments. It is straightforward to see that in equilibrium all agents of same type will make the same decision. Since there is no heterogeneity within each type of agents, we continue to denote the consumption and shareholdings of ESG ($NESG$) agents with a superscript esg ($nesg$). The fraction of ESG

agents is given by $k \in [0,1]$ as before, but their endowments are no longer identical to the $NESG$ agents'. Let λ_ψ denote the ratio of the endowments of consumption goods of each ESG agent to that of each $NESG$ agent, i.e., $\psi_t^{esg} = \lambda_\psi \psi_t^{nesg}$ for $t = 1$ and 2. Similarly, we let λ_θ be the ratio of the initial shares of each firm owned by each ESG agent to that of each $NESG$ agent, i.e., $\theta_{B0}^{esg} = \lambda_\theta \theta_{B0}^{nesg}$ and $\theta_{G0}^{esg} = \lambda_\theta \theta_{G0}^{nesg}$. In what follows, we set $\lambda \equiv \lambda_\psi = \lambda_\theta$ for simplicity and name λ as the individual wealth ratio. The homogeneous cases studied in Sections 5.2.1–5.2.3 correspond to $\lambda = 1$.

Since the intuition behind the results in the homogeneous endowments cases does not depend on homogeneity *per se*, we expect the theoretical results of the homogeneous endowments case to continue to hold for the heterogeneous endowments case. However, under heterogeneous endowments, as the population size changes, we need to adjust either the individual endowments or the aggregate endowments in a somewhat arbitrary manner, which makes the economic intuition unclear and the proofs of propositions unnecessarily complicated. Hence, we rely on numerical examples in this section.

Instead of presenting all the numerical results, we will provide comparisons of individual utilities relative to the corresponding Benchmark equilibrium for various combinations of individual wealth ratio λ and fraction k of ESG population. The rest of the numerical results as well as discussions can be found in the Internet Appendix IA.5.

In the homogeneous endowments case ($\lambda = 1$), the individual utilities remain constant with respect to k in the Benchmark equilibrium. Under heterogeneous endowments, however, Benchmark utilities will vary for different combinations of k and λ as agents face different initial wealth. Figure 8 plots the heat maps of level changes in individual ESG and $NESG$ agents' utilities relative to the corresponding Benchmark. The black and red dashed curves in each sub-figure indicate combinations of $(\bar{k}, \bar{\lambda})$ and $(\bar{\bar{k}}, \bar{\bar{\lambda}})$, respectively. The area to the left of the black curve represents the region where share prices under the Exit or Boycott strategies are identical to Benchmark prices. In this region, the Exit or Boycott strategy has no price impact, which ultimately leads to the same consumption plans and same utilities as in the Benchmark equilibrium.

The next region is where the Exit or Boycott strategy has an effect on share prices but the brown share price is not sufficiently depressed to have the green technology adopted.

This region is between the two dashed curves. We observe that as k becomes larger, we need a smaller λ to enter this region; also, as λ becomes larger, we need a smaller k. This is consistent with the intuition of Figure 2 that the aggregate wealth of ESG agents needs to be large enough to make an impact on share prices. We observe that the ESG ($NESG$) agents are worse (better) off relative to the Benchmark. This is because the Exit strategy causes the price of green shares to increase, and the ESG agents are restricted to holding the more expensive green shares only. Similarly, the Boycott strategy dampens the brown consumption good price at $t = 3$, and the ESG agents can consume only the more expensive green consumption goods.

The last region of our interest is the technology adoption region to the right of the red curve. When individual ESG agents become poorer, a higher fraction of them will be required to have the brown firm's manager adopt the green technology when it is available. For ESG agents, we observe that the poorer they are, the larger utility gain they will receive when the green technology is adopted. This is because a poor ESG agent only consumes a small fraction of the outputs, but prior to adoption of the green technology the public bad affects everyone equally. A wealthy $NESG$ agent, on the other hand, enjoys more consumption goods but is not subject to more public bad. The disutility from the public bad has a higher weight in the overall utility of a poor ESG agent than a wealthy $NESG$ agent. Therefore, removing the public bad through the green technology will have a larger positive effect for individual ESG agents. Indeed, we see that for $NESG$ agents, the wealthier they are, the smaller utility gain they will have after the technology adoption.

Furthermore, for a fixed λ, both $\bar{k}$ and $\bar{\bar{k}}$ in the Boycott equilibrium are smaller than those in the Exit equilibrium. Similarly, given k, both $\bar{\lambda}$ and $\bar{\bar{\lambda}}$ are also smaller in the Boycott equilibrium. This shows that even under heterogeneous endowments, the Boycott strategy is still more effective than the Exit in terms of requiring lower aggregate wealth of ESG agents.

Finally, Figure 9 shows the changes in individual utilities relative to the corresponding Benchmark under the Voice strategy. To the left of the red curve, the utility levels are identical to the Benchmark as ESG agents in aggregate do not hold more than 50% of the brown shares. The region between the red and white curves is the one where the ESG

manager is voted in for the brown firm as ESG agents are the majority but not the only shareholders. In this region, the ESG agents have a higher utility relative to the Benchmark. The utility gain is larger when λ is smaller for the same reason as in the Exit and Boycott cases. When the ESG agents hold all of the brown shares in the region to the right of the white curve, they experience a utility loss compared with the Benchmark. This is because the ESG agents have to bear the high initial cost of the brown shares at $t = 1$, but once the green technology is adopted the two types of shares are essentially the same, which shows that an effective Voice strategy can be very costly to ESG agents. This feature can also be found in Figure 6 for the homogeneous endowments case.

6.1.1 Summary of equilibria under various strategies

Our analysis shows that the wealth of ESG agents play a crucial role in determining share prices and the green technology adoption (4.4) under all activist strategies — Exit, Boycott, and Voice. When ESG agents collectively are much poorer than $NESG$ agents taken together as a group, their actions will not have any material impact on equilibrium prices. Thus, all three activist strategies will render the same equilibrium as the Benchmark equilibrium. When the aggregate wealth of ESG agents is large enough, their actions will be reflected in equilibrium prices. Only when the wealth of ESG agents is high enough, which causes a large equilibrium price impact, will the green technology be adopted, if available. We summarize the threshold levels of λ under different activist strategies in Table 4.

6.2 Heterogeneous firm sizes

In this section, we extend the examples in Section 5.2 by allowing firms to have different sizes ($D_{B3} \neq D_{G3}$). Every agent still has identical endowments in shares and consumption goods. Except for the firm sizes, we use the same parameters as in Section 5.2. We fix the total output size to be the same as the previous section, i.e., $D_{B3} + D_{G3} = 1.14$, and vary the ratio of firm G's output to firm B's, denoted by ζ. Figure 10 plots the relationship between the technology adoption threshold $\bar{\bar{k}}$ and relative firm size ζ for all three activist strategies. We also provide examples for two particular values of ζ in the Internet Appendix IA.6.

There are several important observations. First, for each given firm size ratio ζ, the blue curve for Boycott is always to the left of red curve for Exit. As a result, in regions E and F, the green technology is adopted under Boycott but not under Exit. This echos the result in Proposition 5.4 that Boycott is always more effective than Exit in terms of requiring fewer ESG agents in the population for the green technology to be adopted. Second, for Exit and Boycott, as the green firm becomes larger, the adoption threshold also increases. This is because a larger green firm makes both Exit and Boycott more difficult to affect the equilibrium share prices as a higher aggregate wealth of ESG agents is needed to absorb all the green shares or green consumption goods. This consequently increases the adoption threshold. For Voice, the situation is the opposite. As the brown firm becomes smaller, the brown share price also decreases, which makes it easier for the ESG agents to hold the majority of brown shares. Thus, as the green firm becomes larger (or equivalently the brown firm becomes smaller), the adoption threshold decreases. Indeed, in region B where ζ is sufficiently large, the green technology is adopted only under Voice. Finally, when the brown firm is sufficiently large, Voice becomes the least effective and has the largest $\bar{\bar{k}}$ among all three activist strategies. In region D, the green technology is adopted under both Exit and Boycott but not under Voice. These results are reflected in Proposition 5.6.

6.2.1 Numerical calibration and discussion

One way to assess the effectiveness of the three strategies is to calibrating the firm sizes using the 10 Industry Portfolios in Ken French's data library.[39] The energy industry consists of oil, gas, and coal companies, which represent about 3.6% by value. If we use the energy industry as a proxy for the brown firm, the relative size of the green firm is $\zeta = 27.8$.

Using this value with other parameters as in Table 1, Exit and Boycott require $\bar{\bar{k}}$ to be 0.971 and 0.968, respectively.[40] Voice, on the other hand, will be the most effective strategy as it only requires $\bar{\bar{k}}$ to be less than 2%.

All three strategies have limitations we have not modeled. Exit and Voice work only for public companies, but firms may become private in response to activism. Boycott,

[39] mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

[40] A contemporaneous work by Berk and van Binsbergen (2022) studies the effectiveness of Exit and reaches a similar conclusion.

requires that consumers are able to identify the origins of consumption goods, and substitutes for brown goods must be available. Even with limitations, activism may increase public awareness of environmental issues among both the wealthy and poor and hence increase the chance of legislative enactment of Pigouvian taxes and subsidies.[41]

7 Summary and Conclusion

We develop a three-period model economy with two firms, one green and one brown, where the brown firm generates a negative externality when producing the consumption good. With some probability, a costly technology becomes available, which permits the brown firm to become green. Agents in the economy are atomistic and cannot individually affect adoption of the green technology. However, their action in the aggregate can affect equilibrium share prices and induce the brown firm manager to adopt the green technology if and when it becomes available. Pollution risk abatement through technology adoption depends on the number of activists in the economy, which in reality is endogenous. While we do not model this endogeneity, we characterize this dependence.

We examine three possible strategies that activist agents in the economy may follow: Exit, Boycott, and Voice. We find that Exit and Boycott have much in common. A low fraction of activists has no effect on share prices, and a sufficiently high fraction of activists induces the brown firm manager to adopt the green technology. With an intermediate fraction of activists, green shares sell at a large premium relative to brown shares but the green technology is not adopted. The thresholds that the fraction of activist agents need to cross for Boycott are lower than those for Exit, suggesting that Boycott may be a more effective strategy.

Voice requires a much lower threshold than Exit and Boycott, provided that the brown firm is not too large. Nevertheless, when activists become the only shareholders of the brown firm (leading to technology adoption), they incur a significant personal cost due to initially buying brown shares at a large premium. This observation is in contrast to Exit and Boycott,

[41]In contrast to Voice, Pigouvian taxes and subsidies may lead to development of clean alternatives to brown technology. The rise of the photovoltaic solar industry is an example.

under which all agents have the same utility after technology adoption. Furthermore, there are several impediments to implementing Voice in practice. For example, not all shares may have equal voting power, a few agents may control most of the votes, and it may not be easy to get a shareholder resolution on the proxy-ballot for voting. All these will limit the effectiveness of Voice.

We find that relative firm size and the initial wealth of activists also play an important role in technology adoption. The larger the green firm is, the less effective the Exit and Boycott strategies become, since their aggregate effect on equilibrium share prices are smaller. The opposite occurs for the Voice strategy — a larger brown firm makes the strategy less effective. When activists are wealthier, their aggregate wealth and consumption will be larger and their actions have a larger impact on share prices. Therefore, all of the activist strategies become more effective.

Increasing concerns about pollution can lead to an unexpected increase in the number of activists. When the economy shifts from there being no activists to a large number of activists, green shares can trade at a huge premium to brown shares, even after accounting for emissions tax. For example, when $k = 0$, the price ratio of brown to green shares is 0.909 while the ratio becomes 0.808 when $k = 0.57$.

Reality is more complex since firms in practice may go private as a response to activist pressure. Privatization stymies both Exit and Voice strategies and would be appealing to agents who do not care about a firm's negative externality. Boycott, by contrast, does not require shares to be publicly traded. However, it assumes that agents know the source of the consumption good and the associated public bad. In practice, accurately labeling goods as green may be difficult, especially with a globally distributed supply chain.

When a sufficiently high emissions tax is imposed on brown output through legislative action, the brown firm's manager will adopt the green technology whenever it is available, leading to the socially optimal outcome. Given enough activists, all three activist strategies can also achieve the socially optimal outcome of converting the brown firm to green, but in practice, for reasons we have outlined, there may be no real alternative to legislative action. That said, legislative action requires awareness, and activism plays an important role in increasing awareness.

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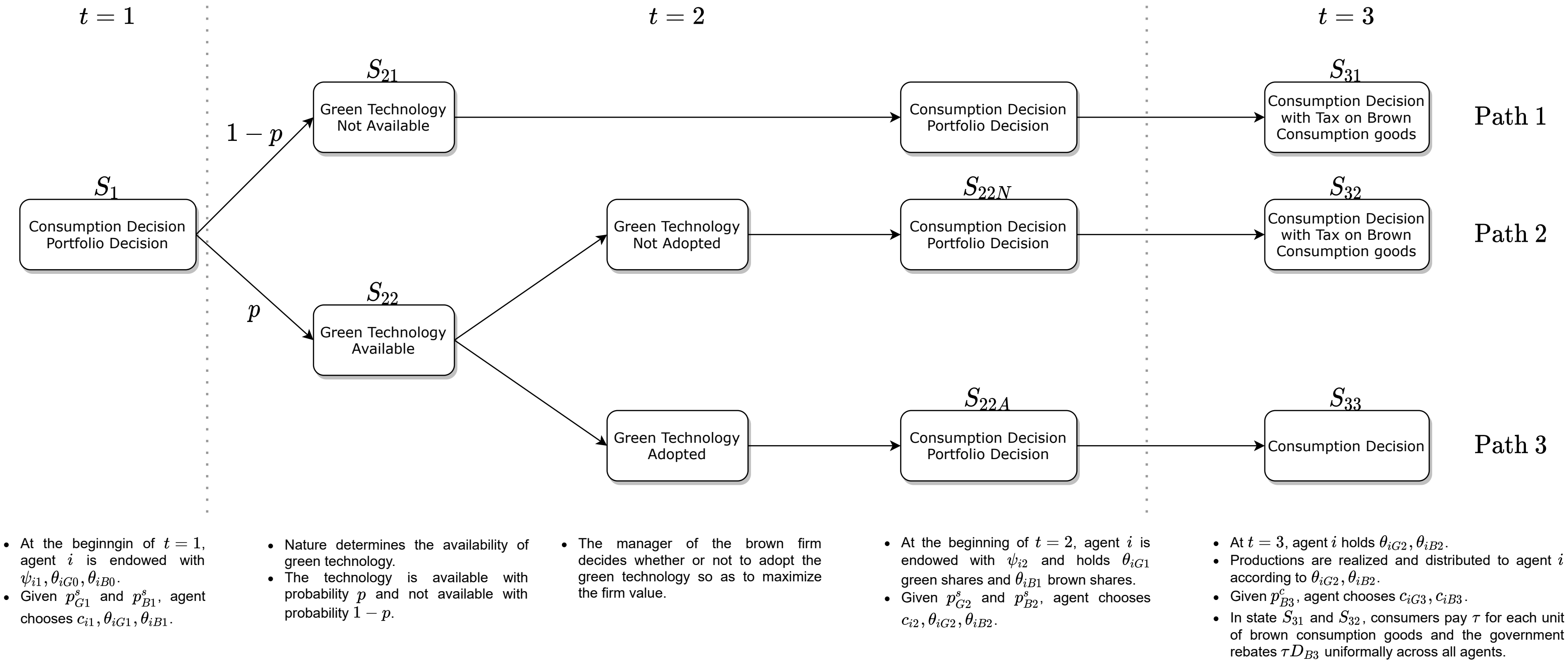
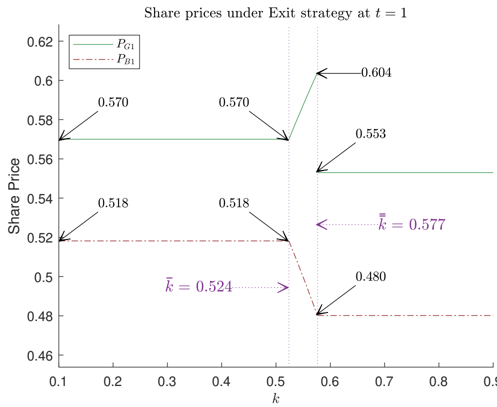
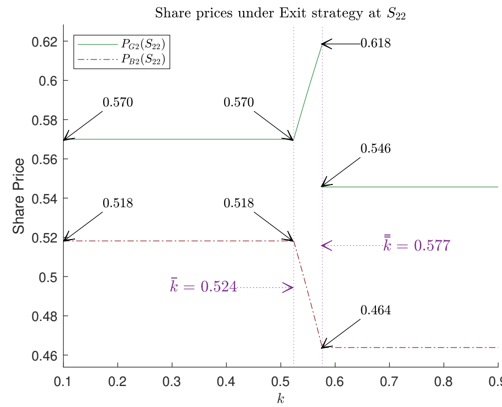


Figure 1: Timeline of the model. The symbols S_1–S_{33} represent the "state" of the economy. For states S_{21} and S_{22}, the first subscript denotes the time and the second subscript indicates the availability or unavailability of the green technology. For states S_{22N} and S_{22A}, the third subscript indicates whether firm B's manager adopts the green technology when available. For states S_{31}, S_{32} and S_{33}, the first subscript denotes the time and the second subscript indicates unavailability of the green technology or the manager's decision to adopt or not when the green technology is available. Paths $1, 2$ and 3 denote possible equilibrium paths. In equilibrium, only one of the three paths will ex post be realized. Manager's decision to adopt or not adopt the green technology will determine whether Path 2 or 3 will be realized when the green technology is available.

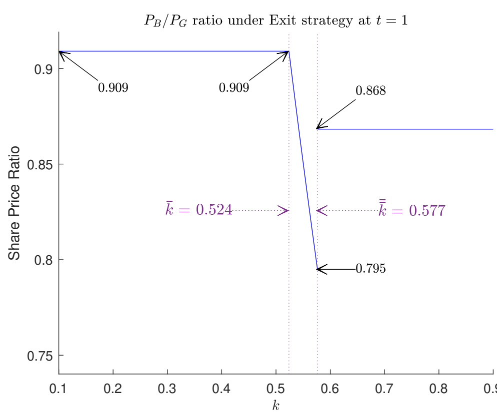


(a) Share prices at $t = 1$

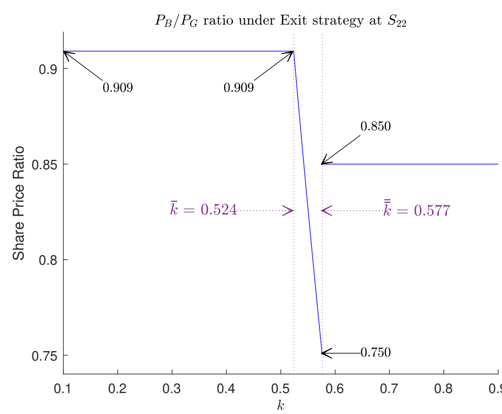


(b) Share prices at S_{22}

Figure 2: Exit - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1.



(a) Share price ratio at $t = 1$



(b) Share price ratio at S_{22}

Figure 3: Exit - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1.

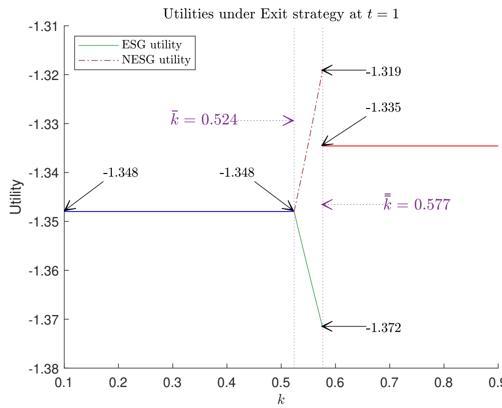
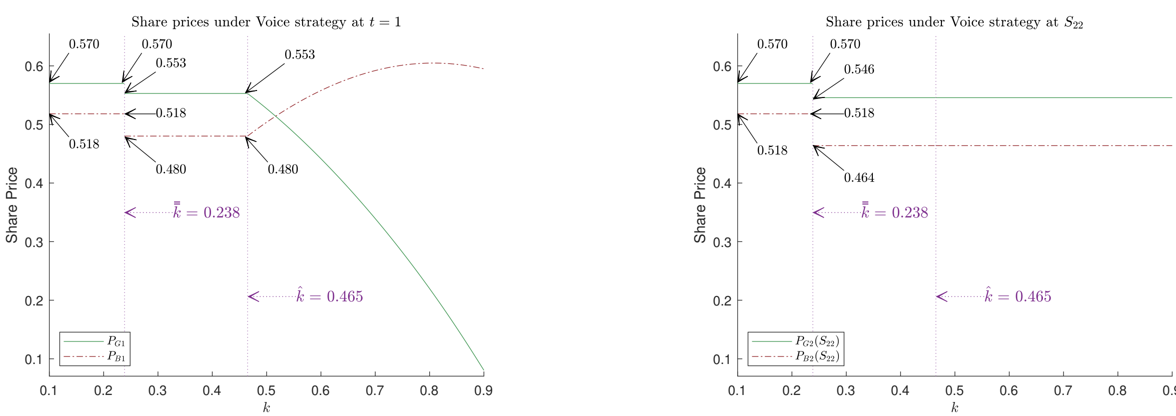


Figure 4: Exit - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{k}$. The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k \in [\bar{k}, \bar{\bar{k}}]$. The red line is the utility level for both ESG and $NESG$ agents when $k > \bar{\bar{k}}$. Parameters are from Table 1.



(a) Share prices at $t = 1$

(b) Share prices at S_{22}

Figure 5: Voice - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{k}}$) or all of firm B's shares ($\hat{k}$). Parameters are from Table 1.

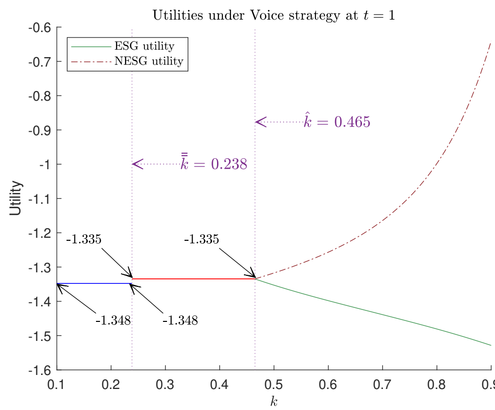


Figure 6: Voice - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents. The purple dotted lines denote the threshold level of k, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{k}}$) or all of firm B's shares ($\hat{k}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{\bar{k}}$. The red line is the utility level for both ESG and $NESG$ agents when $k \in [\bar{\bar{k}}, \hat{k}]$. The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k > \hat{k}$. Parameters are from Table 1.

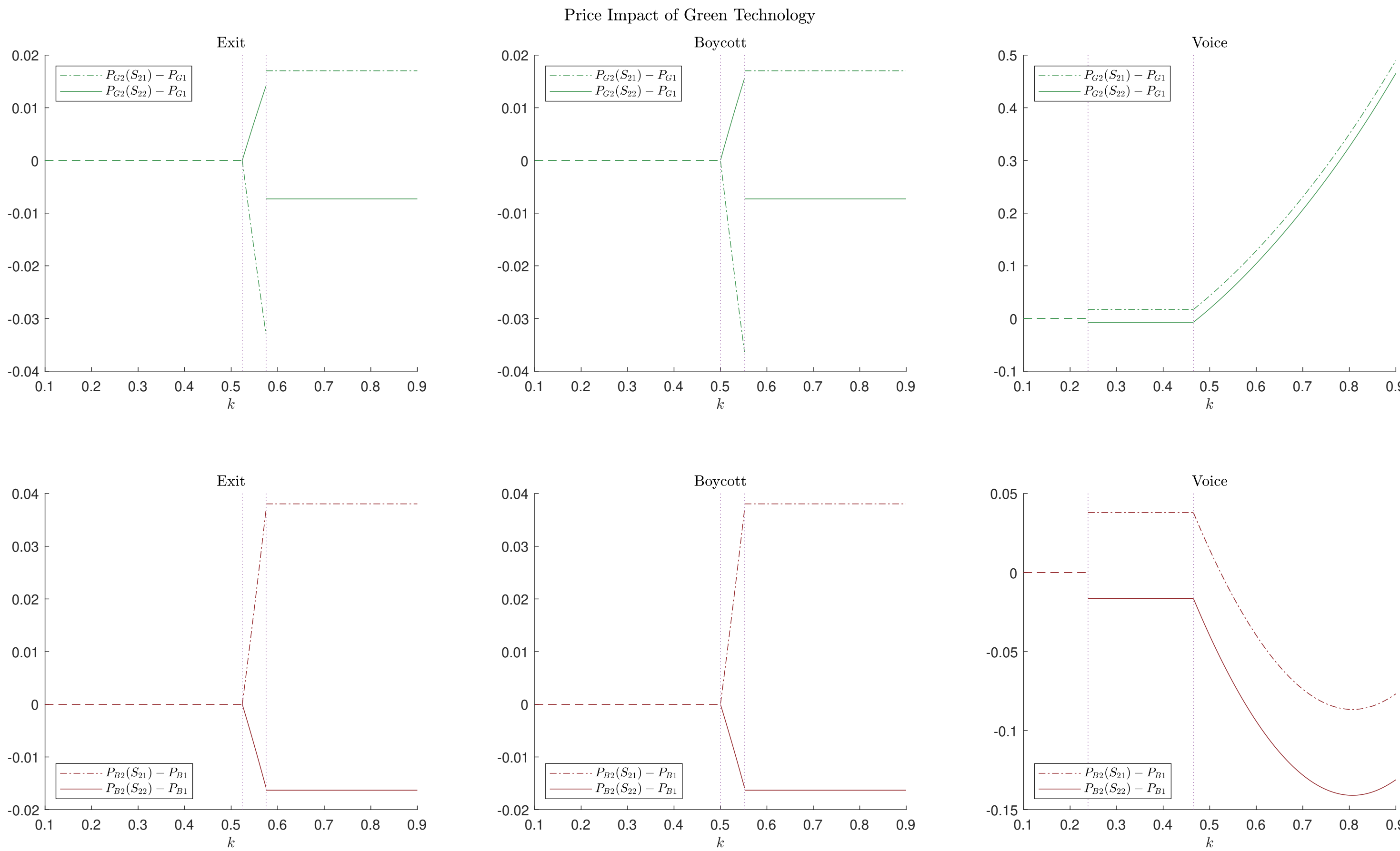
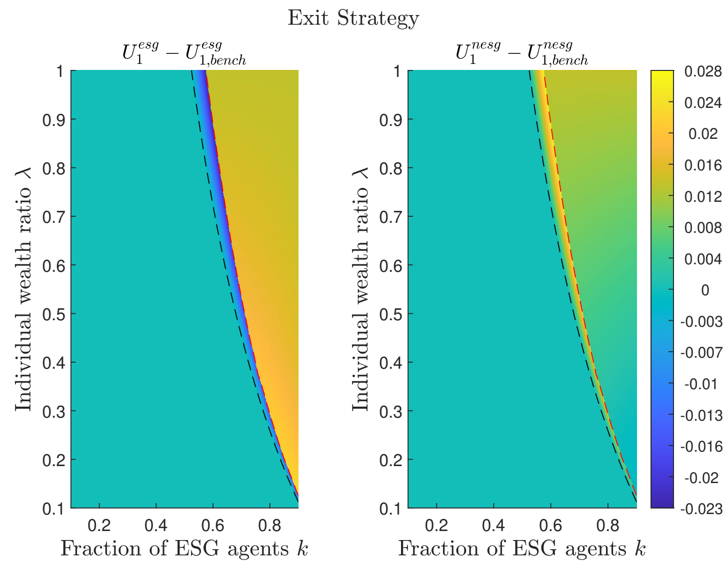
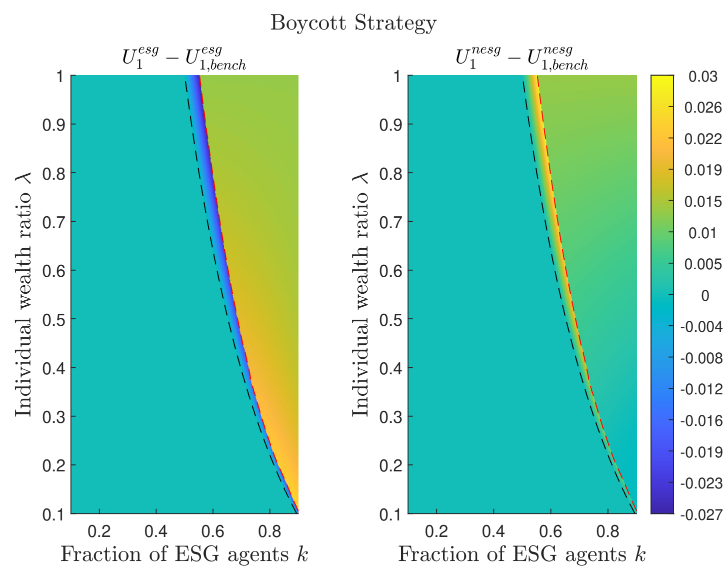


Figure 7: Price impact of the green technology. This figure plots difference between period-2 and period-1 share prices as functions of the fraction k of ESG agents. In each subfigure, the left dotted purple line denotes the threshold levels of k, beyond which the Exit and Boycott strategies have a price impact and ESG agents as a whole either hold the majority but not all of firm B's shares under Voice. The right dotted purple line denotes the threshold levels of k, beyond which firm B's manager to adopt the green technology under Exit and Boycott and the ESG agents as a whole hold all of firm B's shares. Parameters are from Table 1.



(a) Change in utilities under Exit



(b) Change in utilities under Boycott

Figure 8: Exit and Boycott - change in individual utilities at $t = 1$ relative to the Benchmark. This figure plots change in utility levels of individual agents relative to the Benchmark at $t = 1$ for various individual wealth ratios λ and fractions k of ESG agents. A positive change indicates an agent's utility is higher under the Exit or Boycott strategy than the Benchmark, and vice versa. The dashed black and red curves represent combinations of thresholds for individual wealth ratios λ and fractions k of ESG agents. Share prices coincide with those in the Benchmark in the region to the left of the black curve. Exit and Boycott strategies impact the share prices between the black and red curves. The green technology is adopted, if available, in the region to the right of the red curve. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.

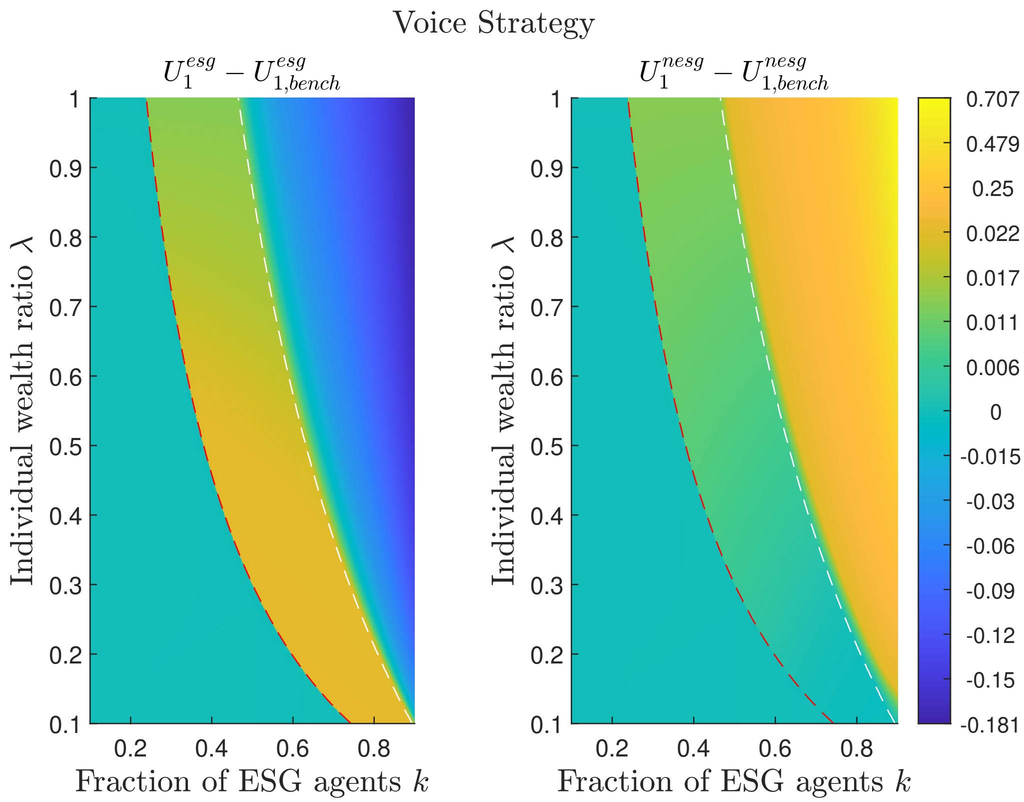


Figure 9: Voice - change in individual utilities at $t = 1$ relative to the Benchmark. This figure plots change in utility levels of individual agents relative to the Benchmark at $t = 1$ for various individual wealth ratios λ and fractions k of ESG agents. A positive change indicates an agent's utility is higher under the Voice strategy than the Benchmark, and vice versa. The dashed red and white curves represent combinations of thresholds for individual wealth ratios λ and fractions k of ESG agents. Share prices coincide with those in the Benchmark in the region to the left of the black curve. The green technology is adopted, if available, in the region between the black and red curves. All of the brown shares are held by the ESG agents in the region to the right of the red curve. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.

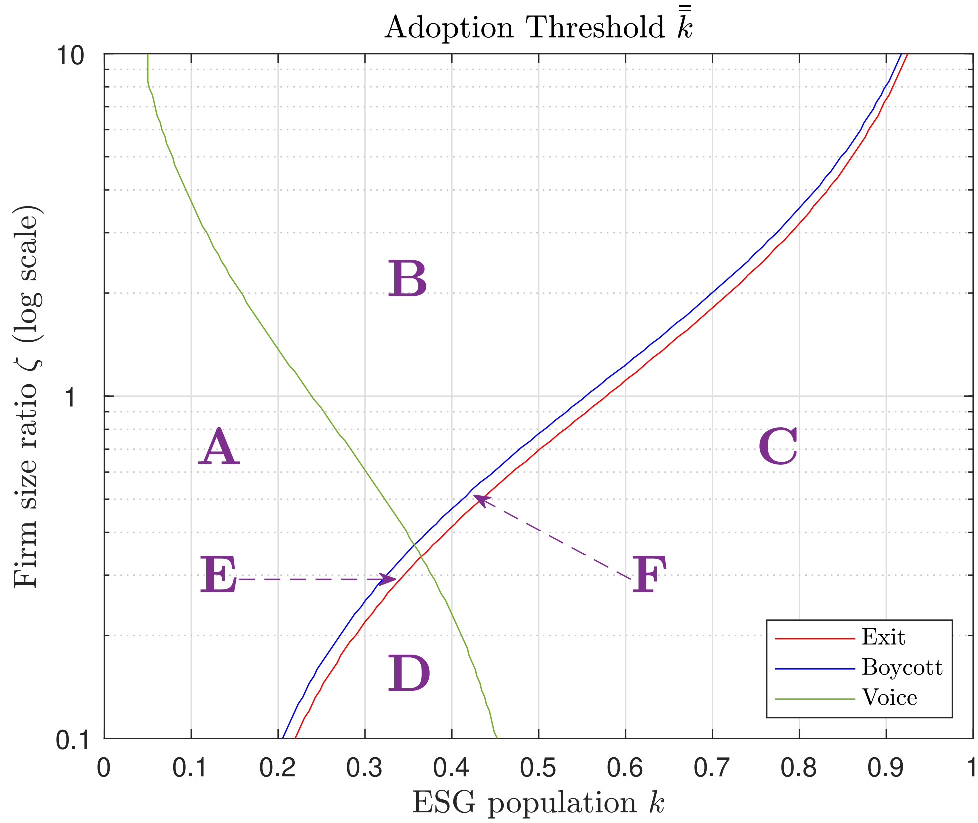


Figure 10: Comparison of activist strategies for different firm sizes. This figure plots the adoption threshold $\bar{\bar{k}}$ for each of the three activist strategies as the firm size ratio $\zeta = \frac{D_{G3}}{D_{B3}}$ varies. The vertical axis is on a log scale. For Exit, the green technology is adopted in regions C and D. For Boycott, the technology is adopted in regions C, D, E, and F. For Voice, the technology is adopted in regions B, C, and F. In region A, none of the activist strategies adopts the technology. Parameters are from Table 1 except that individual firm size varies and we fix $D_{G3} + (1-\delta)D_{B3} = 1$ so that the interest rate is still zero under each respective benchmark equilibrium.

Table 1: Base-case parameters for examples. This table reports the baseline parameters used in the numerical examples. Endowments in the table refer to individual endowments of a type-i agent, where $i \in \{esg, nesg\}$. All agents of same type receive identical endowments. Aggregate endowments are computed as follows: $k\psi_1^{esg} + (1-k)\psi_1^{nesg} = \psi_1, k\psi_2^{esg} + (1-k)\psi_2^{nesg} = \psi_2, k\theta_{B0}^{esg} + (1-k)\theta_{B0}^{nesg} = \theta_{B0}$, and $k\theta_{G0}^{esg} + (1-k)\theta_{G0}^{nesg} = \theta_{G0}$.

Description	Parameter	Value
Individual endowment of consumption good, $t = 1, 2$	$\psi_1^i, \psi_2^i, i \in \{esg, nesg\}$	1
Individual endowment of brown and green shares, $t = 1$	$\theta_{B0}^i, \theta_{G0}^i, i \in \{esg, nesg\}$	1
Aggregate endowment of consumption good, $t = 1, 2$	ψ_1, ψ_2	1
Aggregate endowment of brown and green shares, $t = 1$	θ_{B0}, θ_{G0}	1
CARA coefficient	A	0.8
Emissions tax	τ	0.1
Probability of green technology existence	p	0.7
Output reduction from adopting green technology	η	0.15
Scale factor for public bad	δ	0.2456
Dividends from brown and green firms, $t = 3$	D_{B3}, D_{G3}	0.57

Table 2: Exit - equilibrium and off-equilibrium values. This table reports the equilibrium and off-equilibrium values for three fractions k of ESG population. An off-equilibrium is defined such that the green technology is not but should have been adopted, and vice versa. Parameters are from Table 1. Off-equilibrium values are denoted by †. Share holdings that do not have a unique value are denoted by *. We use $\wedge$ to denote that the share holdings depend on holdings labeled by * in the same state.

	Symbols	$k = 0.3 < \bar{k}$	$\bar{k} < k = 0.54 < \bar{\bar{k}}$	$\bar{\bar{k}} < k = 0.65$
Price deviation	-	No	Yes	No
Adoption	-	No	No	Yes
Share prices	(p^s_{G1}, p^s_{B1})	$(0.570, 0.518)$	$(0.581, 0.507)$	$(0.553, 0.480)$
	$(p^s_{G2}, p^s_{B2})\ (S_{21})$	$(0.570, 0.518)$	$(0.570, 0.518)$	$(0.570, 0.518)$
	$(p^s_{G2}, p^s_{B2})\ (S_{22N})$	$(0.570, 0.518)$	$(0.586, 0.502)$	$(0.679, 0.374)^\dagger$
	$(p^s_{G2}, p^s_{B2})\ (S_{22A})$	$(0.546, 0.464)^\dagger$	$(0.546, 0.464)^\dagger$	$(0.545, 0.464)$
Returns	$(G_{22N\to 32}, B_{22N\to 32})$	$(0, 0)$	$(-0.027, 0.032)$	$(-0.161, 0.385)^\dagger$
	$(G_{22A\to 33}, B_{22A\to 33})$	$(0.045, 0.045)^\dagger$	$(0.045, 0.045)^\dagger$	$(0.045, 0.045)$
Holdings	$(\theta^{esg}_{G1}, \theta^{nesg}_{G1})$	$(1, 1)$	$(0.873, 1.149)$	$(1, 1)$
	$(\theta^{esg}_{B1}, \theta^{nesg}_{B1})$	$(1, 1)$	$(1.143, 0.832)$	$(1, 1)$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\ (S_{21})$	$(1, 1)^*$	$(0.873, 1.149)^*$	$(1, 1)^*$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\ (S_{21})$	$(1, 1)^\wedge$	$(1.141, 0.834)^\wedge$	$(1, 1)^\wedge$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\ (S_{22N})$	$(1.909, 0.610)$	$(1.852, 0)$	$(1.538, 0)^\dagger$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\ (S_{22N})$	$(0, 1.429)$	$(0, 2.174)$	$(0, 2.857)^\dagger$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\ (S_{22A})$	$(1, 1)^{\dagger *}$	$(1, 1)^{\dagger *}$	$(1, 1)^*$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\ (S_{22A})$	$(1, 1)^{\dagger \wedge}$	$(0.997, 1.003)^{\dagger \wedge}$	$(1, 1)^\wedge$
Consumption	(c^{esg}_1, c^{nesg}_1)	$(1, 1)$	$(1.001, 0.999)$	$(1, 1)$
	$(c^{esg}_2, c^{nesg}_2)\ (S_{21})$	$(1, 1)$	$(1.001, 0.999)$	$(1, 1)$
	$(c^{esg}_2, c^{nesg}_2)\ (S_{22N})$	$(1, 1)$	$(1.001, 0.999)$	$(1.008, 0.985)^\dagger$
	$(c^{esg}_2, c^{nesg}_2)\ (S_{22A})$	$(1, 1)^\dagger$	$(0.998, 1.002)^\dagger$	$(1, 1)$
	$(c^{esg}_3, c^{nesg}_3)\ (S_{31})$	$(1.140, 1.140)$	$(1.141, 1.139)$	$(1.140, 1.140)$
	$(c^{esg}_3, c^{nesg}_3)\ (S_{32})$	$(1.140, 1.140)$	$(1.107, 1.178)$	$(0.929, 1.532)^\dagger$
	$(c^{esg}_3, c^{nesg}_3)\ (S_{33})$	$(1.055, 1.055)^\dagger$	$(1.053, 1.056)^\dagger$	$(1.055, 1.055)$
Utility	(U^{esg}_1, U^{nesg}_1)	$(-1.348, -1.348)$	$(-1.355, -1.339)$	$(-1.335, -1.335)$
	$(U^{esg}_2, U^{nesg}_2)\ (S_{21})$	$(-0.899, -0.899)$	$(-0.898, -0.899)$	$(-0.899, -0.899)$
	$(U^{esg}_2, U^{nesg}_2)\ (S_{22N})$	$(-0.899, -0.899)$	$(-0.910, -0.886)$	$(-0.978, -0.783)^\dagger$
	$(U^{esg}_2, U^{nesg}_2)\ (S_{22A})$	$(-0.879, -0.879)^\dagger$	$(-0.880, -0.878)^\dagger$	$(-0.879, -0.879)$
	$(U^{esg}_3, U^{nesg}_3)\ (S_{31})$	$(-0.449, -0.449)$	$(-0.449, -0.450)$	$(-0.449, -0.449)$
	$(U^{esg}_3, U^{nesg}_3)\ (S_{32})$	$(-0.449, -0.449)$	$(-0.461, -0.436)$	$(-0.532, -0.328)^\dagger$
	$(U^{esg}_3, U^{nesg}_3)\ (S_{33})$	$(-0.430, -0.430)^\dagger$	$(-0.431, -0.430)^\dagger$	$(-0.430, -0.430)$

Table 3: Thresholds comparison. This table reports the thresholds $\bar{k}, \bar{\bar{k}}$ and $\hat{k}$ for different activist strategies. Parameters are from Table 1.

	$\bar{k}$	$\bar{\bar{k}}$	$\hat{k}$
Exit	0.524	0.577	-
Boycott	0.500	0.553	-
Voice	-	0.238	0.465

Table 4: Thresholds comparison. This table reports the thresholds $\bar{\lambda}, \bar{\bar{\lambda}}$ and $\hat{\lambda}$ for different activist strategies when $k = 0.65$. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.

	$\bar{\lambda}$	$\bar{\bar{\lambda}}$	$\hat{\lambda}$
Exit	0.576	0.695	-
Boycott	0.505	0.611	-
Voice	-	0.158	0.461

A Proofs

We first prove Proposition 5.1. For that purpose, we develop several lemmas. Lemma A.1 identifies the prices of brown consumption goods at $t = 3$ for different states. The share prices of the brown firm in states S_{22A} and S_{22N} are examined in Lemmas A.2 and A.3, respectively. Then, we prove Proposition 5.1 using Lemmas A.1–A.3. Furthermore, Lemma A.4 characterizes the Benchmark equilibrium, the properties of which will be used for proving subsequent propositions.

The discount factor between $t = 2$ and $t = 3$ is

$$M_A\left(c_2, c_3\right) = e^{Ac_2 - A(c_3 - \eta D_{B3})} \tag{A.1}$$

$$M_N\left(c_2, c_3\right) = e^{Ac_2 - A(c_3 - \delta D_{B3})}, \tag{A.2}$$

where c_2 and c_3 are consumption at $t = 2$ and 3, $M_A\left(c_2, c_3\right)$ represents the marginal rate of substitution between states S_{22A} and S_{33} and $M_N\left(c_2, c_3\right)$ represents the discount factor in period 2 when the green technology is not adopted (in states S_{21}, S_{22N}). Also, we define ψ_1 and ψ_2 as

$$\psi_1 = k\psi_1^{esg} + (1-k)\,\psi_1^{nesg} \tag{A.3}$$

$$\psi_2 = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg}, \tag{A.4}$$

where k represents of the fraction of ESG agents and ψ_t^i denotes the type-i agent's endowment of consumption at time t, where $t \in \{1, 2\}$ and $i \in \{esg, nesg\}$.

Lemma A.1. *In the Benchmark equilibrium, Exit equilibrium, and Voice equilibrium, $p^c_{B3} = 1$ in state S_{33} and $p^c_{B3} = \frac{1}{1+\tau}$ in states S_{31} and S_{32}. Furthermore, for a Boycott equilibrium, $p^c_{B3} = \frac{1}{1+\tau}$ in state S_{31} and $p^c_{B3} = 1$ in state S_{33}.*

Proof of Lemma A.1 Note that in any state of the Benchmark equilibrium, Exit equilibrium, or Voice equilibrium, there is no restriction on buying consumption goods from the brown firm. Hence, a $NESG$ agent i maximizes $c_{iG3} + c_{iB3}$ in (4.3). If $p^c_{B3} > \frac{1}{1+\tau(1-\mathbf{1}(S_{33}))}$, agent i will not consume any brown consumption goods. If $p^c_{B3} < \frac{1}{1+\tau(1-\mathbf{1}(S_{33}))}$, agent i will not consume any green consumption goods. Hence, the market clearing conditions for consumption goods cannot be satisfied. Thus, in the Benchmark, Exit, and Voice equilibria, the equilibrium price of brown consumption good at $t = 3$ satisfies $p^c_{B3} = \frac{1}{1+\tau(1-\mathbf{1}(S_{33}))}$.

Similarly, for a Boycott equilibrium, there is no restriction on buying consumption goods from firm B in states S_{31} and S_{33}. Thus, $p^c_{B3} = \frac{1}{1+\tau}$ in state S_{31} and $p^c_{B3} = 1$ in state S_{33}. □

Lemma A.2. *In the Benchmark equilibrium, Exit equilibrium, Boycott equilibrium, and Voice equilibrium, the equilibrium price p^s_{B2} in state S_{22A} is given by*

$$p^s_{B2} = M_A\left(\psi_2, D_{B3}\left(1-\eta\right) + D_{G3}\right) D_{B3},$$

where the discount factor M_A is defined by (A.1).

Proof of Lemma A.2 From Lemma A.1, $p^c_{B3} = 1$. Hence, U_{i3} in (4.3) simplifies to

$$U_{i3}\left(\theta_{iG2}, \theta_{iB2}\right) = -e^{-A(\theta_{iG2} D_{G3} + \theta_{iB2} D_{B3}(1-\eta))},$$

which in conjunction with U_{i2} in (4.2) implies that

$$U_{i2}\left(\theta_{iG1}, \theta_{iB1}\right) = \max_{\theta_{iG2}, \theta_{iB2}, c_{i2}} \left\{-e^{-Ac_{i2}} - e^{-A(\theta_{iG2} D_{G3} + \theta_{iB2} D_{B3}(1-\eta))}\right\},$$

subject to the budget constraint:

$$c_{i2} = \theta_{iG1} p^s_{G2} + \theta_{iB1} p^s_{B2} + \psi_{i2} - \theta_{iG2} p^s_{G2} - \theta_{iB2} p^s_{B2}.$$

Then, the FOC with respect to θ_{iB2} yields

$$-e^{-Ac_{i2}} p^s_{B2} + (1-\eta) D_{B3} e^{-A(\theta_{iG2} D_{G3} + \theta_{iB2} D_{B3}(1-\eta))} = 0,$$

which gives

$$p^s_{B2} = e^{Ac_{i2} - A(\theta_{iG2} D_{G3} + \theta_{iB2} D_{B3}(1-\eta))} D_{B3}\left(1-\eta\right).$$

Hence,

$$\log\left(\frac{p^s_{B2}}{D_{B3}\left(1-\eta\right)}\right) = Ac_{i2} - A\left(\theta_{iG2} D_{G3} + \theta_{iB2} D_{B3}\left(1-\eta\right)\right),$$

which, integrated over i, gives

$$\begin{aligned}\log\left(\frac{p^s_{B2}}{D_{B3}\left(1-\eta\right)}\right) &= \int_{i\in[0,1]} Ac_{i2} - A\left(\theta_{iG2} D_{G3} + \theta_{iB2} D_{B3}\left(1-\eta\right)\right) di \\ &= A\left(k\psi_2^{esg} + \left(1-k\right)\psi_2^{nesg}\right) - A\left(D_{B3}\left(1-\eta\right) + D_{G3}\right),\end{aligned}$$

where the last equality is from the market clearing conditions. Hence, with (A.1), the lemma follows. □

Lemma A.3. *In the Benchmark equilibrium and Voice equilibrium, the equilibrium price p^s_{B2} in state S_{22N} is given by*

$$p^s_{B2} = M_N\left(\psi_2, D_{B3}(1-\delta) + D_{G3}\right) D_{B3} \frac{1}{1+\tau},$$

where the discount factor M_N is defined by (A.2).

Proof of Lemma A.3 The logic is similar to the proof of Lemma A.2. From Lemma A.1, $p^c_{B3} = \frac{1}{1+\tau}$. Hence, U_{i3} in (4.3) simplifies to

$$U_{i3}\left(\theta_{iG2}, \theta_{iB2}\right) = -e^{-A\left(\theta_{iG2} D_{G3} + \theta_{iB2} \frac{1}{1+\tau} D_{B3} + \frac{\tau}{1+\tau} D_{B3} - \delta D_{B3}\right)},$$

which in conjunction with U_{i2} in (4.2) that

$$U_{i2}\left(\theta_{iG1}, \theta_{iB1}\right) = \max_{\theta_{iG2}, \theta_{iB2}, c_{i2}} \left\{-e^{-Ac_{i2}} - e^{-A(c_{i3} - \delta D_{B3})}\right\},$$

subject to the budget constraints:

$$c_{i2} = \theta_{iG1} p_{G2}^s + \theta_{iB1} p_{B2}^s + \psi_{i2} - \theta_{iG2} p_{G2}^s - \theta_{iB2} p_{B2}^s$$
$$c_{i3} = \theta_{iG2} D_{G3} + \theta_{iB2} \frac{D_{B3}}{1+\tau} + \frac{\tau}{1+\tau} D_{B3}.$$

Then, the FOC with respect to θ_{iB2} yields

$$-e^{-Ac_{i2}} p_{B2}^s + \frac{D_{B3}}{1+\tau} e^{-A(c_{i3}-\delta D_{B3})} = 0,$$

which gives

$$p_{B2}^s = e^{Ac_{i2} - A\left(\theta_{iG2} D_{G3} + \theta_{iB2} \frac{D_{B3}}{1+\tau} + \frac{\tau}{1+\tau} D_{B3} - \delta D_{B3}\right)} \frac{D_{B3}}{1+\tau}.$$

Integrating the above over i gives

$$\begin{aligned}\log\left(\frac{p_{B2}^s (1+\tau)}{D_{B3}}\right) &= \int_{i\in[0,1]} Ac_{i2} - A\left(\theta_{iG2} D_{G3} + \theta_{iB2} \frac{D_{B3}}{1+\tau} + \frac{\tau}{1+\tau} D_{B3} - \delta D_{B3}\right) di \\ &= A\left(k\psi_2^{esg} + (1-k)\,\psi_2^{nesg}\right) - A\left(D_{B3}(1-\delta) + D_{G3}\right),\end{aligned}$$

where the last equality is from the market clearing conditions. Hence, with (A.2), the lemma follows. □

Proof of Proposition 5.1 Let $p_{B2}^s(S_{22A})$ and $p_{B2}^s(S_{22N})$ denote the share prices of the brown firm in states S_{22A} and S_{22N}, respectively. Lemmas A.2 and A.3 imply that

$$\begin{aligned}\frac{p_{B2}^s(S_{22N})}{p_{B2}^s(S_{22A})} &= \frac{M_N(\psi_2, D_{B3} + D_{G3}) \frac{D_{B3}}{1+\tau}}{M_A(\psi_2, D_{B3}(1-\eta) + D_{G3})\, D_{B3}(1-\eta)} \\ &= \frac{e^{A(\delta-\eta)D_{B3}}}{(1-\eta)(1+\tau)} > 1,\end{aligned}$$

where the second equality is from (A.1) and (A.2), and the inequality is from $\tau < \overline{\tau}$ and (5.1). According to the technology adoption rule (4.4), the default brown firm manager does not adopt the green technology. This completes the proof of the proposition. □

Now, we are ready to characterize the Benchmark equilibrium. Let $(\theta_{G0}^{esg}, \theta_{B0}^{esg}, \psi_1^{esg}, \psi_2^{esg})$ and $(\theta_{G0}^{nesg}, \theta_{B0}^{nesg}, \psi_1^{nesg}, \psi_2^{nesg})$ denote the endowments of a representative ESG and $NESG$ agent, respectively. Note that we use superscript of esg and $nesg$ even in the Benchmark equilibrium for the ease of comparison to the equilibrium with ESG agents.

Lemma A.4. *We have the following results for the Benchmark equilibrium.*
(i) The equilibrium consumption vector of ESG agents $(c_1^{esg}, c_2^{esg}, c_{G3}^{esg} + c_{B3}^{esg})$ *satisfies*

$$(c_1^{esg}, c_2^{esg}, c_{G3}^{esg} + c_{B3}^{esg}) = (\psi_1, \psi_2, D_{G3} + D_{B3}) + \gamma^{esg} \cdot (1,1,1), \tag{A.5}$$

for some constant γ^{esg}.

(ii) The equilibrium share prices of $(p^s_{G1}, p^s_{B1}, p^s_{G2})$ are given by

$$\begin{aligned} p^s_{G2} &= M_N\left(\psi_2, D_{G3}+D_{B3}\right) D_{G3}, \\ p^s_{G1} &= e^{A(\psi_1-\psi_2)} p^s_{G2}, \\ p^s_{B1} &= p^s_{G1} \frac{D_{B3}}{D_{G3}\left(1+\tau\right)}, \end{aligned} \tag{A.6}$$

where M_N is given by (A.2).
(iii) γ^{esg} in (A.5) satisfies

$$\gamma^{esg} = \frac{\left(\theta^{esg}_{G0}-1\right) p^s_{G1} + \left(\theta^{esg}_{B0}-1\right) p^s_{B1} + \left(\psi^{esg}_1 - \psi_1\right) + \frac{p^s_{G1}}{p^s_{G2}}\left(\psi^{esg}_2 - \psi_2\right)}{\left(1 + \frac{p^s_{G1}}{p^s_{G2}} + \frac{p^s_{G1}}{D_{G3}}\right)}. \tag{A.7}$$

When the endowments are the same across all agents,

$$\gamma^{esg} = 0. \tag{A.8}$$

A.1 Exit and Boycott equilibria

We prove Propositions 5.2–5.4 in this subsection. Lemma A.5 characterizes the conditions where Exit and Boycott equilibria are equivalent to the Benchmark equilibrium. Lemmas A.6 and A.7 examine the Benchmark equilibrium when the fraction of *ESG* agents is very small or very large. Then, we prove Propositions 5.2 and 5.3, which establish Exit and Boycott equilibria when the fraction of *ESG* agents is small such that the equilibrium quantities coincide with those in the Benchmark equilibrium. Next, we move to the opposite case where the fraction of *ESG* agents is sufficiently large such that the brown firm manager will adopt the green technology when available. In particular, it is important to investigate state S_{22N} on the off-equilibrium path. Lemma A.8 characterizes the equilibria in state S_{22N} under Exit. Lemma A.9 analyzes it under Boycott. Lemma A.10 compares the two equilibria in Lemmas A.8 and A.9. Finally, we prove Propositions 5.2 and 5.3 as well as Proposition 5.4.

The following lemma establishes the conditions whether the equilibrium share prices in the Benchmark equilibrium are the same as those in the Exit or Boycott equilibria.

Lemma A.5. *Even in the presence of ESG agents, if the fraction of ESG agents, k, is small enough to satisfy the conditions given below, the resulting equilibrium prices under exit and boycott will be the same as the prices in the Benchmark equilibrium.*

$$\text{Exit: } k\left(D_{G3}+D_{B3}+\gamma^{esg}\right) < D_{G3} + \frac{k\tau}{1+\tau} D_{B3} \tag{A.9}$$

$$\text{Boycott: } k\left(D_{G3}+D_{B3}+\gamma^{esg}\right) < D_{G3} \tag{A.10}$$

where γ^{esg} is given in Lemma A.4.

The next two lemmas examine the Benchmark equilibrium when the fraction of *ESG* agents is very small or very large.

Lemma A.6. *Consider the Benchmark equilibrium. Assume that, as the fraction of ESG agents $k \to 0$, $k\theta_{G0}^{esg} \to 0$, $k\theta_{B0}^{esg} \to 0$, $k\theta_{G0}^{esg} + (1-k)\,\theta_{G0}^{nesg} = k\theta_{B0}^{esg} + (1-k)\,\theta_{B0}^{nesg} = 1$. Then,*

$$\lim_{k\to 0} p_{G2}^{s} = M_N\left(\psi_2^{nesg}, D_{G3} + D_{B3}\right) D_{G3}, \tag{A.11}$$

$$\lim_{k\to 0} p_{G1}^{s} = e^{A\left(\psi_1^{nesg} - \psi_2^{nesg}\right)} \lim_{k\to 0} p_{G2}^{s}, \tag{A.12}$$

$$\lim_{k\to 0} p_{B1}^{s} = \frac{D_{B3}}{D_{G3}\,(1+\tau)} \lim_{k\to 0} p_{G1}^{s}, \tag{A.13}$$

and $\lim_{k\to 0} \gamma^{esg} \in (K_1, K_2)$ *for some constants* K_1 *and* K_2.

Proof The claims (A.11)–(A.13) directly follow from Lemma A.4(ii). Furthermore, from the expression (A.7) and the boundedness of $\lim_{k\to 0} p_{G2}^{s}$, $\lim_{k\to 0} p_{G1}^{s}$ and $\lim_{k\to 0} p_{B1}^{s}$ given in (A.11)–(A.13), the boundedness of $\lim_{k\to 0} \gamma^{esg}$ is straightforward. This completes the proof of the lemma. □

Lemma A.7. *Consider the Benchmark equilibrium. Assume that, as the fraction of ESG agents $k \to 1$, $k\theta_{G0}^{esg} \to 1$, $k\theta_{B0}^{esg} \to 1$, $k\theta_{G0}^{esg} + (1-k)\,\theta_{G0}^{nesg} = k\theta_{B0}^{esg} + (1-k)\,\theta_{B0}^{nesg} = 1$. Then,*

$$\lim_{k\to 1} p_{G2}^{s} = M_N\left(\psi_2^{esg}, D_{G3} + D_{B3}\right) D_{G3}, \tag{A.14}$$

$$\lim_{k\to 1} p_{G1}^{s} = e^{A\left(\psi_1^{esg} - \psi_2^{esg}\right)} \lim_{k\to 1} p_{G2}^{s}, \tag{A.15}$$

$$\lim_{k\to 1} p_{B1}^{s} = \frac{D_{B3}}{D_{G3}\,(1+\tau)} \lim_{k\to 1} p_{G1}^{s}, \tag{A.16}$$

and $\lim_{k\to 1} \gamma^{esg} = 0$.

Proof The claims (A.14)–(A.16) directly follow from Lemma A.4(ii). Furthermore, from the expression (A.7) and the boundedness of $\lim_{k\to 1} p_{G2}^{s}$, $\lim_{k\to 1} p_{G1}^{s}$ and $\lim_{k\to 1} p_{B1}^{s}$ given in (A.14)–(A.16), because $\theta_{G0}^{esg} \to 1$, $\theta_{B0}^{esg} \to 1$, $\psi_1^{esg} - \psi_1 \to 0$, $\psi_2^{esg} - \psi_2 \to 0$, the numerator of γ^{esg} converges to zero while the denominator is strictly positive in the limit. Hence, $\lim_{k\to 1} \gamma^{esg} = 0$. This completes the proof of the lemma. □

With the lemmas established above, we are now ready to prove Propositions 5.2 and 5.3.

Proof of Propositions 5.2 and 5.3 From Lemma A.5 and Proposition 5.1, it suffices to show that the inequality (A.9) holds for an Exit equilibrium and (A.10) for a Boycott equilibrium. As $k \to 0$, γ^{esg} is bounded according to Lemma A.6. Hence, (A.9) holds for an Exit equilibrium and (A.10) holds for a Boycott equilibrium. This completes the proof of the first half of the propositions. □

Next, we move to the case where the fraction of *ESG* agents is sufficiently large and examine the equilibria in the off-equilibrium state S_{22N}.

Lemma A.8. *In state S_{22N} when the equilibrium prices under Exit (5.4) are different from the Benchmark equilibrium prices, they have the following properties.*

(i) The following relations hold along equilibrium and off-equilibrium paths, irrespective of whether the green technology is adopted in equilibrium:

$$p_{G2}^{s} = M_N\left(c_2^{esg}, \frac{D_{G3}}{k} + \frac{\tau}{1+\tau}D_{B3}\right)D_{G3} \tag{A.17}$$

$$p_{B2}^{s} = M_N\left(c_2^{nesg}, \frac{D_{B3}}{1-k}\frac{1}{1+\tau} + \frac{\tau}{1+\tau}D_{B3}\right)\frac{D_{B3}}{1+\tau} \tag{A.18}$$

$$0 = \left(p_{B2}^{s}\frac{1}{1-k} + c_2^{nesg}\right) - \left(p_{G2}^{s}\theta_{G1}^{nesg} + p_{B2}^{s}\theta_{B1}^{nesg} + \psi_2^{nesg}\right) \tag{A.19}$$

$$0 = \left(kc_2^{esg} + (1-k)c_2^{nesg}\right) - \left(k\psi_2^{esg} + (1-k)\psi_2^{nesg}\right), \tag{A.20}$$

where M_N is given by (A.2).
(ii) As $k \to 1$, $p_{B2}^{s} \to 0$.
(iii) When all agents have the same endowments and in equilibrium the green technology is adopted, the off-equilibrium firm B's share price corresponding to not adopting the technology, p_{B2}^{s}, decreases with k in state S_{22N}.

Lemma A.9. *In state S_{22N} when the equilibrium prices under Boycott (5.18) are different from the Benchmark equilibrium prices, they have the following properties.*
(i) The following relations hold along equilibrium and off-equilibrium paths, irrespective of whether the green technology is adopted in equilibrium:

$$p_{G2}^{s} = M_N\left(c_2^{esg}, \frac{D_{G3}}{k}\right)D_{G3} \tag{A.21}$$

$$p_{B2}^{s} = M_N\left(c_2^{nesg}, \frac{D_{B3}}{1-k}\right)\frac{D_{B3}}{1+\tau} \tag{A.22}$$

$$\frac{D_{G3}}{p_{G2}^{s}} = \frac{D_{B3}p_{B3}^{c}}{p_{B2}^{s}} \tag{A.23}$$

$$\frac{D_{B3}p_{B3}^{c}(1+\tau)}{1-k} = \frac{D_{G3}}{p_{G2}^{s}}\left(p_{G2}^{s}\theta_{G1}^{nesg} + p_{B2}^{s}\theta_{B1}^{nesg} + \psi_2^{nesg} - c_2^{nesg}\right) + \tau D_{B3}p_{B3}^{c} \tag{A.24}$$

$$0 = \left(kc_2^{esg} + (1-k)c_2^{nesg}\right) - \left(k\psi_2^{esg} + (1-k)\psi_2^{nesg}\right), \tag{A.25}$$

where M_N is given by (A.2).
(ii) As $k \to 1$, $p_{B2}^{s} \to 0$.
(iii) When all agents have the same endowments and in equilibrium the green technology is adopted, the off-equilibrium firm B's share price corresponding to not adopting the technology, p_{B2}^{s}, decreases with k in state S_{22N}.

Lemma A.10. *In state S_{22N} when the equilibrium prices under Exit (5.4) and Boycott (5.18) are different from the Benchmark equilibrium prices, the brown firm price under the Exit equilibrium, p_{B2}^{s}, is larger than that under the Boycott equilibrium.*

Based on the lemmas above, we prove Propositions 5.2, 5.3, and 5.4.

Proof of Propositions 5.2 and 5.3 Fix a state S_{22} and set $k = \overline{\overline{k}}$. First, we show that when k is close to 1

$$p_{B2}^{s}\left(S_{22A}\right) > p_{B2}^{s}\left(S_{22N}\right).$$

Then, we show that for $k = \overline{\overline{k}} + \varepsilon$, where $\varepsilon \in \left(0, 1 - \overline{\overline{k}}\right)$, the above inequality continues to hold.

Step 1. The equilibrium prices under Exit (5.4) and Boycott (5.18) are different from the Benchmark equilibrium prices as $k \left(= \overline{\overline{k}}\right) \to 1$: From Lemma A.7, $\lim_{k\to 1} \gamma^{esg} = 0$, which shows that the inequalities (A.9) and (A.10) in Lemma A.5 do not hold. Hence, from Lemma A.5, the equilibrium prices under Exit (5.4) as well as the Boycott (5.18) are different from those in the Benchmark.

Step 2. $p^s_{B2}(S_{22N}) \to 0$ as $k \left(= \overline{\overline{k}}\right) \to 1$: From Step 1 and Lemma A.8(ii), the claim holds for an Exit equilibrium. Similarly, from Step 1 and Lemma A.9(ii), the claim holds for a Boycott equilibrium.

Step 3. There exists $\varepsilon > 0$ such that $p^s_{B2}(S_{22A}) > \varepsilon$ as $k \left(= \overline{\overline{k}}\right) \to 1$: Recall that in the state of S_{22A} the green technology is adopted and there is no restriction in trading the shares of the brown firm or consuming the goods from the brown firm. Hence, the claim follows.

Step 4. $p^s_{B2}(S_{22A}) > p^s_{B2}(S_{22N})$ as $k \left(= \overline{\overline{k}}\right) \to 1$: This follows from Steps 2 and 3.

Step 5. Fix $\overline{\overline{k}}$ such that the inequality in Step 4 holds. Then, $p^s_{B2}(S_{22A}) > p^s_{B2}(S_{22N})$ for $k = \overline{\overline{k}} + \varepsilon$, where $\varepsilon \in \left(0, 1 - \overline{\overline{k}}\right)$: This follows from Lemma A.8(ii) for an Exit equilibrium and from A.9(ii) for a Boycott equilibrium.

This completes the proof of the second half of the proposition. □

Proof of Proposition 5.4 Note that there is no difference between Exit and Boycott in the state S_{22A}. Then, given the technology adoption rule (4.4), the Proposition directly follows from Lemma A.10. □

A.2 Voice Equilibrium

Finally, we move to Voice equilibrium. Lemma A.11 establishes the condition on whether the equilibrium share prices and consumption allocations are the same as those in a Voice equilibrium. Then, the proofs for Propositions 5.5 and 5.6 follow.

Lemma A.11. *The Voice equilibrium consumption allocations are the same as the Benchmark equilibrium consumption allocations when the fraction of ESG agents, k, is small, satisfying the following inequality.*

$$k\left(\theta^{esg}_{G0}\frac{D_{G3}(1+\tau)}{D_{B3}} + \theta^{esg}_{B0} + \frac{1}{p^s_{B1}}\left(\psi^{esg}_1 - \psi_1 - \gamma^{esg}\right)\right) < \frac{1}{2}, \tag{A.26}$$

where p^s_{B1} and γ^{esg} are given in Lemma A.4.

Using the lemma above and all the results so far, we prove Propositions 5.5 and 5.6.

Proof of Proposition 5.5 Consider the case $k \to 0$. Then, in conjunction with $\lim_{k\to 0}\gamma^{esg}$ and $\lim_{k\to 0} p^s_{B1}$ in Lemma A.6, the LHS of (A.26) in Lemma A.11 has the following limit

$$\lim_{k\to 0} k\theta^{esg}_{G0}\frac{D_{G3}}{D_{B3}(1-\tau)} + k\theta^{esg}_{B0} + \frac{k}{p^s_{B1}}\left(\psi^{esg}_1 - \psi_1 - \gamma^{esg}\right) = 0 < \frac{1}{2}.$$

Hence, from Lemma A.11, the green technology is not adopted.

Next, consider the case $k \to 1$. Then, in conjunction with $\lim_{k\to 1} \gamma^{esg}$ and $\lim_{k\to 1} p^s_{B1}$ in Lemma A.7, the LHS of (A.26) in Lemma A.11 has the following limit

$$\lim_{k\to 1} k\theta^{esg}_{G0} \frac{D_{G3}}{D_{B3}(1-\tau)} + k\theta^{esg}_{B0} + \frac{k}{p^s_{B1}} \left(\psi^{esg}_1 - \psi_1 - \gamma^{esg}\right) = \frac{D_{G3}(1+\tau)}{D_{B3}} + 1 > \frac{1}{2}.$$

Hence, from Lemma A.11, the *ESG* agents hold the majority of brown shares and the *ESG* manager will be elected, leading to the green technology adoption. This completes the proof of the proposition. □

Proof of Proposition 5.6 First, note that γ^{esg} in Lemma A.4 is zero under homogeneous endowment. Then the first claim follows from Lemma A.5. Move to the second claim. Note that LHS of (A.26) in Lemma A.11 becomes $k\frac{D_{G3}+D_{B3}}{D_{B3}}$. Hence, the second claim follows. This completes the proof of the proposition. □

Internet Appendix to "Environmental Activism, Endogenous Risk, and Stock Prices"*

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August 31, 2022

Abstract

This appendix provides (1) proofs to propositions in the main text, (2) algorithms for solving the model numerically, and (3) additional results and discussions for the cases of homogeneous endowments, endogenous risk, heterogeneous endowments, and heterogeneous firm sizes.

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IA.1 Additional Proofs

Proof of Lemma A.4 We show that the three claims of (i), (ii) and (iii) follow from the definition of the Benchmark equilibrium given in Definition 5.1 specialized to emissions tax. From Proposition 5.1, the green technology is not adopted in the Benchmark equilibrium. Hence, we ignore the uncertainty at $t = 2$ and solve the equilibrium as if the green technology were never available. With this simplification, the consumption vector for a generic agent i can be expressed as a triplet of $(c_{i1}, c_{i2}, c_{iG3} + c_{iB3})$ as in (A.5). Furthermore, because S_{22A} is on the off-equilibrium path, $p^c_{B3} = \frac{1}{1+\tau}$ from Lemma A.1. Also, the lifetime utility U_{i1} in (4.1) simplifies to

$$\begin{aligned} U_{i1} &= U\left(c_{i1}, c_{i2}, c_{iG3} + c_{iB3}\right) \\ &= -e^{-Ac_{i1}} - e^{-Ac_{i2}} - e^{-(A(c_{iG3}+c_{iB3})-\delta D_{B3})}. \end{aligned} \tag{IA.1.1}$$

First, to show (i), we rewrite the budget constraints in (4.1), (4.2) and (4.3) as follows:

$$\begin{aligned} c_{i1} &= \psi_{i1} + \theta_{iG0}p^s_{G1} + \theta_{iB0}p^s_{B1} - \theta_{iG1}p^s_{G1} - \theta_{iB1}p^s_{B1} \\ c_{i2} &= \psi_{i2} + \theta_{iG1}p^s_{G2} + \theta_{iB1}p^s_{B2} - \theta_{iG2}p^s_{G2} - \theta_{iB2}p^s_{B2} \\ c_{iG3} + c_{iB3} &= \theta_{iG2}D_{G3} + \theta_{iB2}\frac{D_{B3}}{1+\tau} + \frac{\tau}{1+\tau}D_{B3}, \end{aligned}$$

which are substituted into $U(\cdot,\cdot,\cdot)$ in (IA.1.1).

Taking the derivative of $U(\cdot,\cdot,\cdot)$ in (IA.1.1) with respect to θ_{iG1}, we have

$$-U_1(\cdot,\cdot,\cdot)\,p^s_{G1} + U_2(\cdot,\cdot,\cdot)\,p^s_{G2} = 0,$$

which can be rewritten as

$$e^{-A(c_{i1}-c_{i2})} = \frac{p^s_{G2}}{p^s_{G1}}. \tag{IA.1.2}$$

In conjunction with goods market clearing conditions for consumption goods, the equation above yields

$$\begin{aligned} c_{i1} - c_{i2} &= \psi_1 - \psi_2 \\ \psi_1 - c_{i1} &= \psi_2 - c_{i2}. \end{aligned} \tag{IA.1.3}$$

Similarly, taking derivative with respect to θ_{iG2}, we have

$$-U_2(\cdot,\cdot,\cdot)\,p^s_{G2} + U_3(\cdot,\cdot,\cdot)\,D_{G3} = 0,$$

which can be rewritten as

$$e^{-A(c_{i2}-(c_{iG3}+c_{iB3})+\delta D_{B3})} = \frac{D_{G3}}{p^s_{G2}}. \tag{IA.1.4}$$

In conjunction with goods market clearing conditions, the above yields

$$\begin{aligned} c_{i2} - (c_{iG3} + c_{iB3}) &= \psi_2 - (D_{G3} + D_{B3}) \\ \psi_2 - c_{i2} &= (D_{G3} + D_{B3}) - (c_{iG3} + c_{iB3}). \end{aligned} \tag{IA.1.5}$$

From (IA.1.3) and (IA.1.5), there exists a constant $\gamma_i \in \mathbb{R}$ such that

$$\psi_1 - c_{i1} = \psi_2 - c_{i2} = (D_{G3} + D_{B3}) - (c_{iG3} + c_{iB3}) = \gamma_i,$$

which confirms the claim (A.5) for the first k agents.

Next, we move to (ii). From (A.5), we have

$$c_{i2} - (c_{iG3} + c_{iB3}) = \psi_2 - D_{G3} - D_{B3},$$

which in conjunction with (IA.1.4) yields

$$e^{-A(\psi_2 - D_{G3} - (1-\delta)D_{B3})} = \frac{D_{G3}}{p^s_{G2}}.$$

This in turn gives

$$p^s_{G2} = e^{A(\psi_2 - D_{G3} - (1-\delta)D_{B3})} D_{G3}. \tag{IA.1.6}$$

Again, from (A.5), we have

$$c_{i1} - c_{i2} = \psi_1 - \psi_2,$$

which in conjunction with (IA.1.2) yields

$$e^{-A(\psi_1 - \psi_2)} = \frac{p^s_{G2}}{p^s_{G1}}.$$

The above can be rewritten as

$$p^s_{G1} = e^{A(\psi_1 - \psi_2)} p^s_{G2}. \tag{IA.1.7}$$

Also, noting that the shares of brown firm and green firm are identical in terms of returns and that $p^c_{B3} = \frac{1}{1+\tau}$, no-arbitrage between $t = 1$ and $t = 3$ yields that

$$\frac{D_{G3}}{p^s_{G1}} = \frac{\frac{D_{B3}}{1+\tau}}{p^s_{B1}},$$

which can be rewritten as

$$p^s_{B1} = p^s_{G1} \frac{D_{B3}}{D_{G3}(1+\tau)}. \tag{IA.1.8}$$

Combining the expression of M_N in (A.2) with (IA.1.6), (IA.1.7) and (IA.1.8) confirms the claim (A.6).

Finally, we move to (iii). For agent i, we equate the price of the equilibrium consumption allocations in (A.5) at $t=1$ to the value of endowment at $t=1$:

$$\psi_1 + \frac{p^s_{G1}}{p^s_{G2}}\psi_2 + p^s_{G1} + \frac{p^s_{B1}}{1-\tau} + \gamma_i\left(1 + \frac{p^s_{G1}}{p^s_{G2}} + \frac{p^s_{G1}}{D_{G3}}\right) = \theta^{esg}_{G0}p^s_{G1} + \theta^{esg}_{B0}p^s_{B1} + \psi^{esg}_1 + \frac{p^s_{G1}}{p^s_{G2}}\psi^{esg}_2,$$

which implies (A.7). The special case of (A.8) follows from imposing homogeneous endowments $\theta^{esg}_{G0} = \theta^{esg}_{B0} = 1, \psi^{esg}_1 = \psi_1$, and $\psi^{esg}_2 = \psi_2$. This completes the proof of the lemma. □

Proof of Lemma A.5 Assume the Benchmark equilibrium. Then, we show that the Exit constraint (5.4) is satisfied under (A.9) and that Boycott constraint (5.18) is satisfied under to (A.10).

First, we examine (A.9) under Exit. Recall the optimal consumption path of ESG agents given by Lemma A.4(i). Hence, the wealth of ESG agents at the beginning of $t=2$ is given by

$$\begin{aligned} w^{esg}_2 &= \psi^{esg}_2 + \frac{p^s_{G2}}{p^s_{G1}}\left(\theta^{esg}_{G0}p^s_{G1} + \theta^{esg}_{B0}p^s_{B1} + \psi^{esg}_1 - c^{esg}_1\right) \\ &= \psi^{esg}_2 + \frac{p^s_{G2}}{p^s_{G1}}\left(\theta^{esg}_{G0}p^s_{G1} + \theta^{esg}_{B0}p^s_{B1} + \psi^{esg}_1 - \left(\psi_1 + \gamma^{esg}\right)\right), \end{aligned}$$

which, in conjunction with $c^{esg}_2 = \psi_2 + \gamma^{esg}$ and Exit constraint (5.4), gives the aggregate demand of the green shares by ESG agents as

$$\begin{aligned} k\theta^{esg}_{G2} &= k\frac{1}{p^s_{G2}}\left(w^{esg}_2 - c^{esg}_2\right) \\ &= k\frac{1}{p^s_{G2}}\left(\psi^{esg}_2 - \psi_2 - \gamma^{esg} + \frac{p^s_{G2}}{p^s_{G1}}\left(\theta^{esg}_{G0}p^s_{G1} + \theta^{esg}_{B0}p^s_{B1} + \psi^{esg}_1 - \left(\psi_1 + \gamma^{esg}\right)\right)\right) \\ &= k\frac{1}{p^s_{G1}}\left(\frac{p^s_{G1}}{p^s_{G2}}\left(\psi^{esg}_2 - \psi_2\right) + \left(\theta^{esg}_{G0}p^s_{G1} + \theta^{esg}_{B0}p^s_{B1} + \psi^{esg}_1 - \psi_1\right) - \gamma^{esg}\left(1 + \frac{p^s_{G1}}{p^s_{G2}}\right)\right) \\ &= k\frac{1}{p^s_{G1}}\left(p^s_{G1} + p^s_{B1} + \gamma^{esg}\left(1 + \frac{p^s_{G1}}{p^s_{G2}} + \frac{p^s_{G1}}{D_{G3}}\right) - \gamma^{esg}\left(1 + \frac{p^s_{G1}}{p^s_{G2}}\right)\right) \\ &= k\frac{1}{p^s_{G1}}\left(p^s_{G1} + p^s_{G1}\frac{D_{B3}}{D_{G3}\left(1+\tau\right)} + \gamma^{esg}\frac{p^s_{G1}}{D_{G3}}\right) = k\left(1 + \frac{D_{B3}}{D_{G3}\left(1+\tau\right)} + \gamma^{esg}\frac{1}{D_{G3}}\right), \end{aligned}$$

where the third equality is from (A.7) and the fourth equality is from (A.6). Hence, we need

$$k\theta^{esg}_{G2} = k\left(1 + \frac{D_{B3}}{D_{G3}\left(1+\tau\right)} + \gamma^{esg}\frac{1}{D_{G3}}\right) < 1,$$

which is equivalent to (A.9).

Next, consider (A.10) under Boycott. From Lemma A.4(i) and Boycott constraint (5.18), the aggregate demand for green consumption good by ESG agents at $t=3$ is

$$kc^{esg}_{G3} = k\left(D_{G3} + D_{B3} + \gamma^{esg}\right).$$

Furthermore, we need that the supply of green consumption good D_{G3} is large enough to meet kc_{G3}^{esg}. Note that (A.10) implies $D_{G3} > kc_{G3}^{esg}$. This completes the proof of the lemma. $\square$

Proof of Lemma A.8 First, we show (i): the system of equations (A.17)–(A.20) are satisfied in state S_{22N}. When the equilibrium prices under Exit (5.4) are different from the Benchmark equilibrium prices, the ESG agents hold only the shares of the green firm and the $NESG$ agents hold only the shares of the brown firm. Hence, each ESG agent will consume the dividends from the green firm $\frac{D_{G3}}{k}$ and the tax rebate $\frac{\tau}{1+\tau}D_{B3}$. Similarly, each $NESG$ agent will consume the dividends from the brown firm $\frac{D_{B3}}{1-k}\frac{1}{1+\tau}$ and the tax rebate $\frac{\tau}{1+\tau}D_{B3}$ in the subsequent state at $t=3$. Furthermore, the ESG agents are the marginal investors for shares of the green firm and the $NESG$ agents are those for shares of the brown firm. Hence, equilibrium share prices satisfy (A.17) and (A.18). The third equation (A.19) is the budget constraint for the $NESG$ agents and the last equation (A.20) is the market clearing condition for the consumption goods, both at $t=2$.

Second, we move to (ii). Assume that there exists $\varepsilon > 0$ such that $p_{B2}^s > \varepsilon$. Then, (A.18) yields $c_2^{nesg} \to \infty$, which in conjunction with (A.20) implies $c_2^{esg} \to -\infty$. Then, from (A.17), $p_{G2}^s \to 0$. Because $p_{B2}^s > \varepsilon$ and $p_{G2}^s \to 0$, we have $\frac{D_{G3}}{p_{G2}^s} > \frac{D_{B3}}{p_{B2}^s(1+\tau)}$. This is a contradiction because $NESG$ agents are supposed to prefer the shares of the brown firm. Hence, $p_{B2}^s \to 0$.

Finally, we establish (iii). Note that in state S_{22N} because the $NESG$ agents strictly prefer the shares of the brown firm to those of the green firm, we have

$$\frac{p_{G2}^s}{p_{B2}^s} > \frac{D_{G3}}{D_{B3}\frac{1}{1+\tau}},$$

which in conjunction with (A.17) and (A.18) implies that

$$\varepsilon_0 \equiv c_2^{esg} - \frac{D_{G3}}{k} - c_2^{nesg} + \frac{D_{B3}}{(1-k)(1+\tau)} > 0. \tag{IA.1.9}$$

Furthermore, if the green technology is adopted, there is no difference between ESG and $NESG$ agents. Hence, all agents hold and consume the equal endowments as their optimal consumption. In conjunction with $\theta_{G1}^{nesg} = \theta_{B1}^{nesg} = 1$, we apply the implicit function theorem to (i) and obtain the following:

$$\frac{dp_{G2}^s}{dk} = p_{G2}^s\left(A\frac{dc_2^{esg}}{dk} + A\frac{D_{G3}}{k^2}\right) \tag{IA.1.10}$$

$$\frac{dp_{B2}^s}{dk} = p_{B2}^s\left(A\frac{dc_2^{nesg}}{dk} - A\frac{D_{B3}}{(1-k)^2}\frac{1}{1+\tau}\right) \tag{IA.1.11}$$

$$0 = \left(\frac{dp_{B2}^s}{dk}\cdot\frac{1}{1-k} + p_{B2}^s\frac{1}{(1-k)^2} + \frac{dc_2^{nesg}}{dk}\right) - \left(\frac{dp_{G2}^s}{dk} + \frac{dp_{B2}^s}{dk}\right) \tag{IA.1.12}$$

$$0 = c_2^{esg} - c_2^{nesg} + \left(k\frac{dc_2^{esg}}{dk} + (1-k)\frac{dc_2^{nesg}}{dk}\right). \tag{IA.1.13}$$

Combining (IA.1.11) and (IA.1.12), we have

$$-p_{B2}^{s}\frac{1}{(1-k)^{2}}-\frac{D_{B3}}{(1-k)^{2}}\frac{1}{1+\tau}=-\frac{dp_{G2}^{s}}{dk}+\left(\frac{k}{1-k}+\frac{1}{p_{B2}^{s}A}\right)\frac{dp_{B2}^{s}}{dk}. \tag{IA.1.14}$$

Next, rearranging (IA.1.13) gives

$$-\varepsilon_{0}=\left(k\left(\frac{dc_{2}^{esg}}{dk}+\frac{D_{G3}}{k^{2}}\right)+(1-k)\left(\frac{dc_{2}^{nesg}}{dk}-\frac{D_{B3}}{(1-k)^{2}}\frac{1}{1+\tau}\right)\right),$$

where ε_0 is given by (IA.1.9). Plugging (IA.1.10) and (IA.1.11) to the above yields

$$-\varepsilon_{0}=k\frac{1}{p_{G2}^{s}A}\frac{dp_{G2}^{s}}{dk}+(1-k)\frac{1}{p_{B2}^{s}A}\frac{dp_{B2}^{s}}{dk}. \tag{IA.1.15}$$

Finally, combining (IA.1.14) and (IA.1.15) gives

$$-\frac{1}{p_{G2}^{s}A}\left(p_{B2}^{s}\frac{1}{(1-k)^{2}}+\frac{D_{B3}}{(1-k)^{2}}\frac{1}{1+\tau}\right)-\varepsilon_{0}=\left(\frac{1}{p_{G2}^{s}A}\left(\frac{k}{1-k}+\frac{1}{p_{B2}^{s}A}\right)+(1-k)\frac{1}{p_{B2}^{s}A}\right)\frac{dp_{B2}^{s}}{dk},$$

which together with the sign of (IA.1.9) confirms $\frac{dp_{B2}^{s}}{dk}<0$, i.e., the claim (iii). This completes the proof of the lemma. □

Proof of Lemma A.9 First, we show (i): the system of equations (A.21)–(A.25) is satisfied in the state S_{22N}. When the equilibrium prices under Boycott (5.18) are different from the Benchmark equilibrium prices, each ESG agent consumes $\frac{D_{G3}}{k}$ in a subsequent state at $t=3$. Furthermore, from the market clearing condition for the consumption goods, each $NESG$ agent consumes $\frac{D_{B3}}{1-k}$ in the subsequent state at $t=3$. Hence, the equilibrium share prices satisfy (A.21) and (A.22). The third equation (A.23) is the equal return restriction, which is necessary for the market clearing conditions for shares to hold. The fourth equation shows that the aggregate value of brown consumption goods, $D_{B3}p_{B3}^{c}(1+\tau)$, is determined by the aggregate wealth of the $NESG$ agents at $t=3$. The last equation (A.25) is the market clearing condition for the consumption goods at $t=2$.

Second, we move to (ii). Assume that there exists $\varepsilon>0$ such that $p_{B2}^{s}>\varepsilon$. Then, (A.22) yields $c_2^{nesg}\to\infty$, which in conjunction with (A.24) implies $p_{B3}^{c}<0$, a contradiction. Hence, $p_{B2}^{s}\to 0$.

Finally, we establish (iii). Note that in state S_{22N}, (A.21) and (A.22) imply

$$\frac{p_{G2}^{s}}{p_{B2}^{s}}=e^{A\left(c_{2}^{esg}-\frac{D_{G3}}{k}\right)-\left(c_{2}^{nesg}-\frac{D_{B3}}{(1-k)}\right)}\frac{D_{G3}}{D_{B3}}(1+\tau),$$

which in conjunction with (A.23) gives

$$\frac{1}{p_{B3}^{c}(1+\tau)}=e^{A\left(c_{2}^{esg}-\frac{D_{G3}}{k}\right)-\left(c_{2}^{nesg}-\frac{D_{B3}}{(1-k)}\right)}>1.$$

Hence, we have

$$\varepsilon_0 \equiv c_2^{esg} - \frac{D_{G3}}{k} - c_2^{nesg} + \frac{D_{B3}}{(1-k)} > 0. \tag{IA.1.16}$$

Also, note that combining (A.23) and (A.24) yields

$$0 = p^s_{B2}\left(\frac{1-\tau}{1-k} + \tau - \theta^{nesg}_{B1}\right) - p^s_{G2}\theta^{nesg}_{G1} - \psi_2^{nesg} + c_2^{nesg}. \tag{IA.1.17}$$

For the proof of (iii), it is convenient to exploit the system of equations in (i), where (A.24) is replaced by (IA.1.17).

If the green technology is adopted, there is no difference between ESG and $NESG$ agents. Hence, all agents hold and consume the equal endowments as the optimal consumption. In conjunction with $\theta^{nesg}_{G1} = \theta^{nesg}_{B1} = 1$, we apply the implicit function theorem to (i), where (A.24) is replaced by (IA.1.17), and obtain the following:

$$\frac{dp^s_{G2}}{dk} = p^s_{G2}\left(A\frac{dc_2^{esg}}{dk} + A\frac{D_{G3}}{k^2}\right) \tag{IA.1.18}$$

$$\frac{dp^s_{B2}}{dk} = p^s_{B2}\left(A\frac{dc_2^{nesg}}{dk} - A\frac{D_{B3}}{(1-k)^2}\right) \tag{IA.1.19}$$

$$\frac{dp^s_{B2}}{dk}D_{G3} = D_{B3}\frac{dp^s_{G2}}{dk}p^c_{B3} + D_{B3}p^s_{G2}\frac{dp^c_{B3}}{dk} \tag{IA.1.20}$$

$$0 = \frac{dp^s_{B2}}{dk}\frac{k(1-\tau)}{1-k} - \frac{dp^s_{G2}}{dk} + \frac{dc_2^{nesg}}{dk} \tag{IA.1.21}$$

$$0 = \left(c_2^{esg} - c_2^{nesg}\right) + k\frac{dc_2^{esg}}{dk} + (1-k)\frac{dc_2^{nesg}}{dk}. \tag{IA.1.22}$$

We rearrange (IA.1.21) to

$$-\frac{D_{B3}}{(1-k)^2} = \frac{dp^s_{B2}}{dk}\frac{k(1-\tau)}{1-k} + \left(\frac{dc_2^{nesg}}{dk} - \frac{D_{B3}}{(1-k)^2}\right) - \frac{dp^s_{G2}}{dk},$$

which in conjunction with (IA.1.19) gives

$$-\frac{D_{B3}}{(1-k)^2} = \left(\frac{k(1-\tau)}{1-k} + \frac{1}{p^s_{B2}A}\right)\frac{dp^s_{B2}}{dk} - \frac{dp^s_{G2}}{dk}. \tag{IA.1.23}$$

Also, rearranging (IA.1.22) gives

$$-\varepsilon_0 = k\left(\frac{dc_2^{esg}}{dk} + \frac{D_{G3}}{k^2}\right) + (1-k)\left(\frac{dc_2^{nesg}}{dk} - \frac{D_{B3}}{(1-k)^2}\right),$$

where ε_0 is given by (IA.1.16). Combining the above with (IA.1.18) and (IA.1.19) yields

$$-\varepsilon_0 = \frac{1-k}{p^s_{B2}A}\frac{dp^s_{B2}}{dk} + \frac{k}{p^s_{G2}A}\frac{dp^s_{G2}}{dk} \tag{IA.1.24}$$

Finally, from (IA.1.23) and (IA.1.24) in conjunction with the sign in (IA.1.16), we confirm that $\frac{dp^s_{B2}}{dk} < 0$, i.e., the claim (iii). This completes the proof of the lemma. $\square$

Proof of Lemma A.10 First, we reformulate the Boycott equilibrium. From (A.23) and (A.24) in Lemma A.9, we have

$$\frac{D_{B3}p^c_{B3}(1+\tau)}{1-k} - \tau p^c_{B3}D_{B3} = \frac{D_{B3}p^c_{B3}}{p^s_{B2}}\left(p^s_{G2}\theta^{nesg}_{G1} + p^s_{B2}\theta^{nesg}_{B1} + \psi^{nesg}_2 - c^{nesg}_2\right),$$

which can be rearranged as

$$\left(\frac{1+k\tau}{1-k}\right)p^s_{B2} + c^{nesg}_2 = p^s_{G2}\theta^{nesg}_{G1} + p^s_{B2}\theta^{nesg}_{B1} + \psi^{nesg}_2. \tag{IA.1.25}$$

We use the subscripts of *exit* and *boycott* to denote the Exit and the Boycott, respectively. From (A.17) and (A.21), we have

$$\begin{aligned}\frac{p^s_{G2,exit}}{p^s_{G2,boycott}} &= e^{A\left(c^{esg}_{2,exit}-c^{esg}_{2,boycott}\right)-A\frac{\tau D_{B3}}{1+\tau}},\\ &= e^{-\frac{1-k}{k}A\left(c^{nesg}_{2,exit}-c^{nesg}_{2,boycott}+\frac{\tau D_{B3}}{1+\tau}\frac{k}{1-k}\right)},\end{aligned} \tag{IA.1.26}$$

where the last equality is from the market clearing conditions. From (A.18) and (A.22), we have

$$\frac{p^s_{B2,exit}}{p^s_{B2,boycott}} = e^{A\left(c^{nesg}_{2,exit}-c^{nesg}_{2,boycott}+\frac{\tau D_{B3}}{(1-k)(1+\tau)}\right)}. \tag{IA.1.27}$$

Finally, subtracting (IA.1.25) from (A.19), we have

$$\begin{aligned}&\frac{p^s_{B2,exit}-p^s_{B2,boycott}}{1-k} - \frac{k\tau}{1-k}p^s_{B2,exit} + c^{nesg}_{2,exit} - c^{nesg}_{2,boycott}\\ &= \left(p^s_{G2,exit}-p^s_{G2,boycott}\right)\theta^{nesg}_{G1} + \left(p^s_{B2,exit}-p^s_{B2,boycott}\right)\theta^{nesg}_{B1},\end{aligned}$$

which can be rearranged to

$$\begin{aligned}&\left(\frac{1}{1-k}-\theta^{nesg}_{B1}\right)\left(p^s_{B2,exit}-p^s_{B2,boycott}\right) - \frac{k\tau}{1-k}p^s_{B2,exit} + \left(c^{nesg}_{2,exit}-c^{nesg}_{2,boycott}\right)\\ &= \left(p^s_{G2,exit}-p^s_{G2,boycott}\right)\theta^{nesg}_{G1}.\end{aligned} \tag{IA.1.28}$$

Next, we verify that $p^s_{B2,exit} \geq p^s_{B2,boycott}$ by showing that the three conditions of (IA.1.26), (IA.1.27) and (IA.1.28) cannot hold simultaneously with $p^s_{B2,exit} < p^s_{B2,boycott}$. Assume $p^s_{B2,exit} < p^s_{B2,boycott}$. Then, from (IA.1.27), we get $c^{nesg}_{2,exit} - c^{nesg}_{2,boycott} + \frac{\tau D_{B3}}{(1-k)(1+\tau)} < 0$, which combined with (IA.1.26) implies $\frac{p^s_{G2,exit}}{p^s_{G2,boycott}} > 1$ but when combined with (IA.1.28) implies $p^s_{G2,exit} - p^s_{G2,boycott} < 0$. This is a contradiction. Hence, $p^s_{B2,exit} \geq p^s_{B2,boycott}$. This completes the proof of the lemma. $\square$

Proof of Lemma A.11 We show that in the Benchmark equilibrium under (A.26) , when ESG agents hold only the shares of the brown firm, they do not the majority of the brown firm's shares. Recall the budget constraint for a generic agent i at $t = 1$:

$$\begin{aligned}\theta_{iG0}p^s_{G1} + \theta_{iB0}p^s_{B1} + \psi_{i1} &= c_{i1} + \theta_{iB1}p^s_{B1} \\ &= \psi_1 + \gamma^{esg} + \theta_{iB1}p^s_{B1},\end{aligned}$$

where the last equality is from Lemma A.4. Hence, rearranging the above yields

$$\begin{aligned}\theta_{iB1} &= \theta_{iG0}\frac{p^s_{G1}}{p^s_{B1}} + \theta_{iB0} + \frac{1}{p^s_{B1}}\left(\psi_{i1} - \left(\psi_1 + \gamma^{esg}\right)\right) \\ &= \theta_{iG0}\frac{D_{G3}\left(1+\tau\right)}{D_{B3}} + \theta_{iB0} + \frac{1}{p^s_{B1}}\left(\psi_{i1} - \left(\psi_1 + \gamma^{esg}\right)\right),\end{aligned}$$

where the last equality is from the same return condition $\frac{D_{G3}}{p^s_{G1}} = \frac{D_{B3}}{p^s_{B1}(1+\tau)}$ in the Benchmark equilibrium. Aggregating the above over ESG agents gives

$$\int_0^k \theta_{iB1}di = k\theta^{esg}_{G0}\frac{D_{G3}\left(1+\tau\right)}{D_{B3}} + k\theta^{esg}_{B0} + \frac{1}{p^s_{B1}}\left(k\psi^{esg}_1 - k\left(\psi_1 + \gamma^{esg}\right)\right).$$

Hence, as long as RHS is less than $\frac{1}{2}$, which is (A.26), the ESG agents do not hold the majority. This completes the proof of the lemma. □

IA.1.1 Probabilistic Adoption of the green technology

In a pure strategy equilibrium, we let the brown firm manager to either adopt or not adopt the green technology in the state S_{22}, the green technology is available. However, we can allow the manager of the brown firm to randomly adopt the green technology as long as the share prices of brown firm are identical over S_{22A} and S_{22N}. Furthermore, if we do not allow the random adoption, an equilibrium may not exist under some parameters of the economy. For example, if the manager assumes that he/she will adopt, the non-adoption may be optimal while if the manager assumes that he/she will not adopt, the adoption may be optimal. In fact, by allowing the random adoption, we can always find an equilibrium (Lemma IA.1.1). More interestingly, we find an equilibrium with random adoption exists around the critical population level $\bar{\bar{k}}$ from which the brown firm manager can adopt the green technology optimally (Lemma IA.1.2).

We need to introduce some notations. Let π be the probability with which the brown firm manager to adopt the green technology in the state S_{22}. To express the share price of brown firm is a function of population level k and probability π, we use $p^s_{B2}\left(S_{22A}, \pi, k\right)$ and $p^s_{B2}\left(S_{22N}, \pi, k\right)$ for the share price of brown firm in the state S_{22A} and state S_{22N}. Next, we define $\Delta\left(\pi, k\right)$ as $p^s_{B2}\left(S_{22A}, \pi, k\right) - p^s_{B2}\left(S_{22N}, \pi, k\right)$. Exploiting the continuity of the economy with respect to k and π, the continuity of Δ is guaranteed. First, we establish the existence of equilibria by allowing random adoption of green technology.

Lemma IA.1.1. *If there is no pure-strategy equilibrium, there exists a mixed-strategy equilibrium.*

Proof Assume that there is no pure equilibria for a certain k. Then, $\Delta(1,k)<0$ because the certain adoption is not optimal and $\Delta(0,k)>0$ because the certain non-adoption is not optimal. From the intermediate value theorem, there is $\pi\in(0,1)$ such that $\Delta(\pi,k)=0$. Hence, there is a mixed-strategy equilibria with the random adoption with the probability π. This completes the proof of the Lemma. $\square$

Next, we show that there exists a mixed strategy equilibria around the critical population level $\bar{\bar{k}}$. Note that this lemma does not imply all mixed-strategy equilibria exist around $\bar{\bar{k}}$.

Lemma IA.1.2. *Pick any $\varepsilon>0$. Then, there exist $\pi\in(0,1)$ and $k\in\left(\bar{\bar{k}}-\varepsilon,\bar{\bar{k}}+\varepsilon\right)$ such that $\Delta(\pi,k)=0$.*

Proof Note that $\Delta\left(1,\bar{\bar{k}}\right)=0$. Also, note that $\frac{\partial p^s_{B2}(S_{22A},\pi,k)}{\partial k}=0$ because the population does not affect the price once the green technology is adopted and that $\frac{\partial p^s_{B2}(S_{22N},1,k)}{\partial k}<0$ from Lemmas A.8(iii) and A.9(iii). Hence,

$$\frac{\partial\Delta(1,k)}{\partial k}>0. \tag{IA.1.29}$$

The claim will be proved by showing that $\Delta(\pi,k)=0$ holds with $\pi\in(0,1)$ and $k\in\left(\bar{\bar{k}}-\varepsilon,\bar{\bar{k}}+\varepsilon\right)$ for each of the following cases, which are collectively exhaustive.

Case 1: $\Delta\left(0,\bar{\bar{k}}\right)>0$

Set $k=\bar{\bar{k}}-\delta$ for a sufficiently small $\delta>0$. Then, it holds that $\Delta(0,k)>0>\Delta(1,k)$, where the first inequality is due to the continuity of Δ in k and the second inequality is from IA.1.29. From the intermediate value theorem, there exists $\pi\in(0,1)$ such that $\Delta(\pi,k)=0$.

Case 2: $\Delta\left(0,\bar{\bar{k}}\right)<0$

Set $k=\bar{\bar{k}}+\delta$ for a sufficiently small $\delta>0$. Then, it holds that $\Delta(0,k)<0<\Delta(1,k)$, where the first inequality is due to the continuity of Δ in k and the second inequality is from IA.1.29. From the intermediate value theorem, there exists $\pi\in(0,1)$ such that $\Delta(\pi,k)=0$.

Case 3: $\Delta\left(0,\bar{\bar{k}}\right)=0$

Case 3-1: $\Delta\left(\pi,\bar{\bar{k}}\right)=0$ for some $\pi\in(0,1)$

The claim holds by construction.

Case 3-2: $\Delta\left(\pi,\bar{\bar{k}}\right)>0$ for all $\pi\in(0,1)$

Note that $\Delta\left(0.5,\bar{\bar{k}}\right)>0$. Set $k=\bar{\bar{k}}-\delta$ for a sufficiently small $\delta>0$. Then, it holds that $\Delta(0.5,k)>0>\Delta(1,k)$, where the first inequality is due to the continuity of Δ in k and the second inequality is from IA.1.29. From the intermediate value theorem, there exists $\pi\in(0.5,1)$ such that $\Delta(\pi,k)=0$.

Case 3-3: $\Delta\left(\pi,\bar{\bar{k}}\right)<0$ for all $\pi\in(0,1)$

Note that $\Delta\left(0.5, \bar{\bar{k}}\right) < 0$. Set $k = \bar{\bar{k}} + \delta$ for a sufficiently small $\delta > 0$. Then, it holds that $\Delta(0.5, k) < 0 < \Delta(1, k)$, where the first inequality is due to the continuity of Δ in k and the second inequality is from IA.1.29. From the intermediate value theorem, there exists $\pi \in (0.5, 1)$ such that $\Delta(\pi, k) = 0$.

This completes the proof of the Lemma. □

IA.2 Numerical Algorithms

The general procedure of our numerical algorithm is that we first solve the model backwardly to obtain equilibrium quantities at $t = 2$ as functions of shareholdings at $t = 1$. Then, we plug these quantities (functions) into equilibrium conditions at $t = 1$ to solve for shareholdings and consumption allocations at $t = 1$. During the process, we check whether the equilibrium prices are identical to the Benchmark prices. Our procedure also gives the technology adoption decision by the brown firm manager. Below, we describe in detail the equilibrium equations at each node of the timeline (Figure 1).[1] In what follows, we assume ESG and $NESG$ agents are homogeneous within their type so that we label the quantities with esg and $nesg$.

IA.2.1 Equilibrium under Exit

State S_{21}.

In this state, ESG agents do not have a preference for green. Thus, the equilibrium is identical to the Benchmark equilibrium.

1. Input[2]
   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, \psi_2^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, \psi_2^{nesg}$
2. Output[3]
   - $\theta_{B2}^{esg}, \theta_{G2}^{esg}, c_2^{esg}, \theta_{B2}^{nesg}, \theta_{G2}^{nesg}, c_2^{nesg}, p_{B2}^s, p_{G2}^s, c_3^{esg}, c_3^{nesg}$
3. Equilibrium conditions
   - $p_{G2}^s = e^{A\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}\right)-A(D_{B3}+D_{G3}-\delta D_{B3})} D_{G3}$
   - $p_{B2}^s = \frac{1}{1+\tau} p_{G2}^s \frac{D_{B3}}{D_{G3}}$
   - $\gamma^{esg} = \dfrac{\theta_{B1}^{esg} p_{B2}^s + \theta_{G1}^{esg} p_{G2}^s + \psi_2^{esg} + \tau p_{B2}^s - \left(k\psi_2^{esg} + (1-k)\psi_2^{nesg} + \frac{p_{G2}^s}{D_{G3}}(D_{B3}+D_{G3})\right)}{1+\frac{p_{G2}^s}{D_{G3}}}$
   - $c_2^{esg} + \theta_{B2}^{esg} p_{B2}^s + \theta_{G2}^{esg} p_{G2}^s = \theta_{B1}^{esg} p_{B2}^s + \theta_{G1}^{esg} p_{G2}^s + \psi_2^{esg}$

[1] Equilibrium equations at $t = 3$ are included in the description of time-2 equilibrium conditions.

[2] Recall that at $t = 2$ we take shareholdings chosen at $t = 1$ as given.

[3] We drop the state indicator (e.g., S_{21}) in these quantities for simplicity. Note that the equilibrium quantities can be different across different states.

- $c_2^{nesg} + \theta_{B2}^{nesg} p_{B2}^s + \theta_{G2}^{nesg} p_{G2}^s = \theta_{B1}^{nesg} p_{B2}^s + \theta_{G1}^{nesg} p_{G2}^s + \psi_2^{nesg}$
- $c_2^{esg} = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg} + \gamma^{esg}$
- $c_2^{nesg} = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg} - \frac{k}{1-k}\gamma^{esg}$
- $c_3^{esg} = D_{B3} + D_{G3} + \gamma^{esg}$
- $c_3^{nesg} = D_{B3} + D_{G3} - \frac{k}{1-k}\gamma^{esg}$
- Set $\theta_{G2}^{esg} = \theta_{G2}^{nesg} = 1$ and back out θ_{B2}^{esg}, θ_{B2}^{nesg} using time-2 budget constraints.

State S_{22A}.

In this state, the two types of shares are the same. Thus, the equilibrium is identical to the Benchmark equilibrium.

1. Input
   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, \psi_2^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, \psi_2^{nesg}$
2. Output
   - $\theta_{B2}^{esg}, \theta_{G2}^{esg}, c_2^{esg}, \theta_{B2}^{nesg}, \theta_{G2}^{nesg}, c_2^{nesg}, p_{B2}^s, p_{G2}^s, c_3^{esg}, c_3^{nesg}$
3. Equilibrium conditions
   - $p_{G2}^s = e^{A\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}\right)-A(D_{G3}+D_{B3}(1-\eta))} D_{G3}$
   - $p_{B2}^s = p_{G2}^s \frac{D_{B3}(1-\eta)}{D_{G3}}$
   - $\gamma^{esg} = \frac{\theta_{B1}^{esg} p_{B2}^s + \theta_{G1}^{esg} p_{G2}^s + \psi_2^{esg} - \left(k\psi_2^{esg} + (1-k)\psi_2^{nesg} + \frac{p_{G2}^s}{D_{G3}}(D_{G3}+D_{B3}(1-\eta))\right)}{1+\frac{p_{G2}^s}{D_{G3}}}$
   - $c_2^{esg} + \theta_{B2}^{esg} p_{B2}^s + \theta_{G2}^{esg} p_{G2}^s = \theta_{B1}^{esg} p_{B2}^s + \theta_{G1}^{esg} p_{G2}^s + \psi_2^{esg}$
   - $c_2^{nesg} + \theta_{B2}^{nesg} p_{B2}^s + \theta_{G2}^{nesg} p_{G2}^s = \theta_{B1}^{nesg} p_{B2}^s + \theta_{G1}^{nesg} p_{G2}^s + \psi_2^{nesg}$
   - $c_2^{esg} = k\psi_2^{esg} + (1-k)\psi_2^{nesg} + \gamma^{esg}$
   - $c_2^{nesg} = k\psi_2^{esg} + (1-k)\psi_2^{nesg} - \frac{k}{1-k}\gamma^{esg}$
   - $c_3^{esg} = D_{G3} + (1-\eta)\, D_{B3} + \gamma^{esg}$
   - $c_3^{nesg} = D_{G3} + (1-\eta)\, D_{B3} - \frac{k}{1-k}\gamma^{esg}$
   - Set $\theta_{G2}^{esg} = \theta_{G2}^{nesg} = 1$ and back out θ_{B2}^{esg}, θ_{B2}^{nesg} using time-2 budget constraints.

State S_{22N}.

We first check whether the equilibrium prices are identical to the Benchmark prices.

1. Input
   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, \psi_2^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, \psi_2^{nesg}$
2. Output

- $B = 1$ (price effect) or 0 (no price effect)

3. Equilibrium conditions

- $p^s_{G2} = e^{A\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}\right)-A(D_{B3}+D_{G3}-\delta D_{B3})}D_{G3}$
- $p^s_{B2} = \frac{1}{1+\tau}p^s_{G2}\frac{D_{B3}}{D_{G3}}$
- $\gamma^{esg} = \frac{\theta_{B1}^{esg}p^s_{B2}+\theta_{G1}^{esg}p^s_{G2}+\psi_2^{esg}+\tau p^s_{B2}-\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}+\frac{p^s_{G2}}{D_{G3}}(D_{B3}+D_{G3})\right)}{1+\frac{p^s_{G2}}{D_{G3}}}$
- $B = \mathbf{1}_{\left(D_{G3}\leq k(D_{B3}+D_{G3}+\gamma^{esg})-k\frac{\tau}{1+\tau}D_{B3}\right)}$.

If $B = 0$, we then solve the equilibrium at S_{22N} as if it is the Benchmark equilibrium.

1. Input

- $\theta_{B1}^{esg}, \theta_{G1}^{esg}, \psi_2^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, \psi_2^{nesg}$

2. Output

- $\theta_{B2}^{esg}, \theta_{G2}^{esg}, c_2^{esg}, \theta_{B2}^{nesg}, \theta_{G2}^{nesg}, c_2^{nesg}, p^s_{B2}, p^s_{G2}, c_3^{esg}, c_3^{nesg}$

3. Equilibrium conditions

- $p^s_{G2} = e^{A\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}\right)-A(D_{B3}+D_{G3}-\delta D_{B3})}D_{G3}$
- $p^s_{B2} = \frac{1}{1+\tau}p^s_{G2}\frac{D_{B3}}{D_{G3}}$
- $\gamma^{esg} = \frac{\theta_{B1}^{esg}p^s_{B2}+\theta_{G1}^{esg}p^s_{G2}+\psi_2^{esg}+\tau p^s_{B2}-\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}+\frac{p^s_{G2}}{D_{G3}}(D_{B3}+D_{G3})\right)}{1+\frac{p^s_{G2}}{D_{G3}}}$
- $c_2^{esg} + \theta_{B2}^{esg}p^s_{B2} + \theta_{G2}^{esg}p^s_{G2} = \theta_{B1}^{esg}p^s_{B2} + \theta_{G1}^{esg}p^s_{G2} + \psi_2^{esg}$
- $c_2^{nesg} + \theta_{B2}^{nesg}p^s_{B2} + \theta_{G2}^{nesg}p^s_{G2} = \theta_{B1}^{nesg}p^s_{B2} + \theta_{G1}^{nesg}p^s_{G2} + \psi_2^{nesg}$
- $c_2^{esg} = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg} + \gamma^{esg}$
- $c_2^{nesg} = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg} - \frac{k}{1-k}\gamma^{esg}$
- $c_3^{esg} = D_{B3} + D_{G3} + \gamma^{esg}$
- $c_3^{nesg} = D_{B3} + D_{G3} - \frac{k}{1-k}\gamma^{esg}$
- $\theta_{B2}^{esg} = 0$ and $\theta_{B2}^{nesg} = \frac{1}{1-k}$
- Back out θ_{G2}^{esg} and θ_{G2}^{nesg} using time-2 budget constraints.

If $B = 1$, we then solve the equilibrium at S_{22N} as follows.

1. Input

- $\theta_{B1}^{esg}, \theta_{G1}^{esg}, \psi_2^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, \psi_2^{nesg}$

2. Output

- $\theta_{B2}^{esg}, \theta_{G2}^{esg}, c_2^{esg}, \theta_{B2}^{nesg}, \theta_{G2}^{nesg}, c_2^{nesg}, p_{B2}^s, p_{G2}^s, c_3^{esg}, c_3^{nesg}$

3. Equilibrium conditions

   - $(\theta_{G2}^{esg}, \theta_{B2}^{esg}, \theta_{G2}^{nesg}, \theta_{B2}^{nesg}) = \left(\frac{1}{k}, 0, 0, \frac{1}{1-k}\right)$
   - $p_{G2}^s = e^{Ac_2^{esg} - \left(Ac_3^{esg} - A\delta D_{B3}\right)} D_{G3}$
   - $p_{B2}^s = e^{Ac_2^{nesg} - \left(Ac_3^{nesg} - A\delta D_{B3}\right)} \frac{1}{1+\tau} D_{B3}$
   - $p_{G2}^s \frac{1}{k} + c_2^{esg} = p_{B2}^s \theta_{B1}^{esg} + p_{G2}^s \theta_{G1}^{esg} + \psi_2^{esg}$
   - $kc_2^{esg} + (1-k)c_2^{nesg} = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg}$
   - $c_3^{esg} = \frac{1}{k} D_{G3} + \frac{\tau}{1+\tau} D_{B3}$
   - $c_3^{nesg} = \frac{1}{1-k}\frac{1}{1+\tau} D_{B3} + \frac{\tau}{1+\tau} D_{B3}$.

State S_1.

1. Input

   - $\theta_{B0}^{esg}, \theta_{G0}^{esg}, \psi_1^{esg}, \psi_2^{esg}, \theta_{B0}^{nesg}, \theta_{G0}^{nesg}, \psi_1^{nesg}, \psi_2^{nesg}$

2. Output

   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, c_1^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, c_1^{nesg}, p_{B1}^s, p_{G1}^s$

3. Equilibrium conditions

   - $p_{G1}^s e^{-Ac_1^{esg}} = pe^{-Ac_2^{esg}(S_{22})} p_{G2}^s(S_{22}) + (1-p)\, e^{-Ac_2^{esg}(S_{21})} p_{G2}^s(S_{21})$
   - $p_{G1}^s e^{-Ac_1^{nesg}} = pe^{-Ac_2^{nesg}(S_{22})} p_{G2}^s(S_{22}) + (1-p)\, e^{-Ac_2^{nesg}(S_{21})} p_{G2}^s(S_{21})$
   - $p_{B1}^s e^{-Ac_1^{esg}} = pe^{-Ac_2^{esg}(S_{22})} p_{B2}^s(S_{22}) + (1-p)\, e^{-Ac_2^{esg}(S_{21})} p_{B2}^s(S_{21})$
   - $p_{B1}^s e^{-Ac_1^{nesg}} = pe^{-Ac_2^{nesg}(S_{22})} p_{B2}^s(S_{22}) + (1-p)\, e^{-Ac_2^{nesg}(S_{21})} p_{B2}^s(S_{21})$
   - $p_{B1}^s \theta_{B1}^{esg} + p_{G1}^s \theta_{G1}^{esg} + c_1^{esg} = p_{B1}^s \theta_{B0}^{esg} + p_{G1}^s \theta_{G0}^{esg} + \psi_1^{esg}$
   - $kc_1^{esg} + (1-k)c_1^{nesg} = k\psi_1^{esg} + (1-k)\psi_1^{nesg}$
   - The actual state of $S_{22} \in \{S_{22A}, S_{22N}\}$ is determined by the brown firm manager's decision specified below.

Firm B manager's technology adoption decision.

In order to determine the technology adoption decision on the equilibrium path, we compare $p_{B2}^s(S_{22A})$ with $p_{B2}^s(S_{22N})$ using the same $\{\theta_{G1}^{esg}, \theta_{B1}^{esg}, \theta_{G1}^{nesg}, \theta_{B1}^{nesg}\}$ and make the adoption decision based on (4.4). Then, S_{22A} (S_{22N}) will be on the equilibrium path if the technology is adopted (not adopted).

IA.2.2 Equilibrium under Boycott

State S_{21}.

Same as the Exit equilibrium.

State S_{22A}.

Same as the Exit equilibrium.

State S_{22N}.

We first check whether the equilibrium prices are identical to the Benchmark prices.

1. Input
   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, \psi_2^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, \psi_2^{nesg}$
2. Output
   - $B = 1\,(\text{price effect})$ or $0\,(\text{no price effect})$
3. Equilibrium conditions
   - $p_{G2}^s = e^{A\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}\right)-A(D_{G3}+D_{B3}-\delta D_{B3})} D_{G3}$
   - $p_{B2}^s = \frac{1}{1+\tau} p_{G2}^s \frac{D_{B3}}{D_{G3}}$
   - $\gamma^{esg} = \frac{\theta_{B1}^{esg} p_{B2}^s + \theta_{G1}^{esg} p_{G2}^s + \psi_2^{esg} + \tau p_{B2}^s - \left(k\psi_2^{esg}+(1-k)\psi_2^{nesg} + \frac{p_{G2}^s}{D_{G3}}(D_{B3}+D_{G3})\right)}{1+\frac{p_{G2}^s}{D_{G3}}}$
   - $B = \mathbf{1}_{(D_{G3} \le k(D_{B3}+D_{G3}+\gamma^{esg}))}$.

If $B = 0$, we then solve the equilibrium at S_{22N} as if it is the Benchmark equilibrium.

1. Input
   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, \psi_2^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, \psi_2^{nesg}$
2. Output
   - $\theta_{B2}^{esg}, \theta_{G2}^{esg}, c_2^{esg}, \theta_{B2}^{nesg}, \theta_{G2}^{nesg}, c_2^{nesg}, p_{B2}^s, p_{G2}^s, c_3^{esg}, c_3^{nesg}$
3. Equilibrium conditions
   - $p_{G2}^s = e^{A\left(k\psi_2^{esg}+(1-k)\psi_2^{nesg}\right)-A(D_{B3}+D_{G3}-\delta D_{B3})} D_{G3}$
   - $p_{B2}^s = \frac{1}{1+\tau} p_{G2}^s \frac{D_{B3}}{D_{G3}}$
   - $\gamma^{esg} = \frac{\theta_{G1}^{esg} p_{G2}^s + \theta_{B1}^{esg} p_{B2}^s + \psi_2^{esg} + \tau p_{B2}^s - \left(k\psi_2^{esg}+(1-k)\psi_2^{nesg} + \frac{p_{G2}^s}{D_{G3}}(D_{B3}+D_{G3})\right)}{1+\frac{p_{G2}^s}{D_{G3}}}$
   - $c_2^{esg} + \theta_{B2}^{esg} p_{B2}^s + \theta_{G2}^{esg} p_{G2}^s = \theta_{B1}^{esg} p_{B2}^s + \theta_{G1}^{esg} p_{G2}^s + \psi_2^{esg}$
   - $c_2^{nesg} + \theta_{B2}^{nesg} p_{B2}^s + \theta_{G2}^{nesg} p_{G2}^s = \theta_{B1}^{nesg} p_{B2}^s + \theta_{G1}^{nesg} p_{G2}^s + \psi_2^{nesg}$
   - $c_2^{esg} = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg} + \gamma^{esg}$
   - $c_2^{nesg} = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg} - \frac{k}{1-k}\gamma^{esg}$
   - $c_3^{esg} = D_{B3} + D_{G3} + \gamma^{esg}$

- $c_3^{nesg} = D_{B3} + D_{G3} - \frac{k}{1-k}\gamma^{esg}$
- Set $\theta_{G2}^{esg} = 1$ and $\theta_{G2}^{nesg} = 1$ and back out θ_{B2}^{esg} and θ_{B2}^{nesg} using time-2 budget constraints.

If $B = 1$, we then solve the equilibrium at S_{22N} as follows.

1. Input
   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, \psi_2^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, \psi_2^{nesg}$
2. Output
   - $\theta_{B2}^{esg}, \theta_{G2}^{esg}, c_2^{esg}, \theta_{B2}^{nesg}, \theta_{G2}^{nesg}, c_2^{nesg}, p_{B2}^s, p_{G2}^s, p_{B3}^c, c_3^{esg}, c_3^{nesg}$
3. Equilibrium conditions
   - $p_{G2}^s = e^{Ac_2^{esg} - \left(Ac_3^{esg} - A\delta D_{B3}\right)} D_{G3}$
   - $p_{B2}^s = e^{Ac_2^{nesg} - \left(Ac_3^{nesg} - A\delta D_{B3}\right)} \frac{1}{1+\tau} D_{B3}$
   - $\frac{D_{G3}}{p_{G2}^s} = \frac{p_{B3}^c D_{B3}}{p_{B2}^s}$
   - $p_{G2}^s \frac{1}{k} + c_2^{esg} = p_{B2}^s \theta_{B1}^{esg} + p_{G2}^s \theta_{G1}^{esg} + \psi_2^{esg} + \tau p_{B2}^s$
   - $kc_2^{esg} + (1-k)c_2^{nesg} = k\psi_2^{esg} + (1-k)\,\psi_2^{nesg}$
   - $c_3^{esg} = \frac{1}{k} D_{G3}$
   - $c_3^{nesg} = \frac{1}{1-k} D_{B3}$
   - Set $\theta_{G2}^{esg} = \theta_{G1}^{esg}$ and $\theta_{G2}^{nesg} = \theta_{G1}^{nesg}$ and back out θ_{B2}^{esg} and θ_{B2}^{nesg} using time-2 budget constraints.

State S_1.

Same as the Exit equilibrium.

Firm B manager's technology adoption decision.

Same as the Exit equilibrium.

IA.2.3 Equilibrium under Voice

State S_{21}.

Same as the Exit equilibrium.

State S_{22A}.

Same as the Exit equilibrium.

State S_{22N}.

Same as state S_{21}.

State S_1.

We first solve the equilibrium assuming ESG agents in aggregate own less than 100% of firm B's shares. We refer to this as the interior equilibrium.

1. Input
   - $\theta_{B0}^{esg}, \theta_{G0}^{esg}, \psi_1^{esg}, \psi_2^{esg}, \theta_{B0}^{nesg}, \theta_{G0}^{nesg}, \psi_1^{nesg}, \psi_2^{nesg}$
2. Output
   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, c_1^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, c_1^{nesg}, p_{B1}^s, p_{G1}^s$
3. From input to output
   - $p_{B1}^s e^{-Ac_1^{esg}} = pe^{-Ac_2^{esg}(S_{22})} p_{B2}^s (S_{22}) + (1-p) e^{-Ac_2^{esg}(S_{21})} p_{B2}^s (S_{21})$
   - $p_{G1}^s e^{-Ac_1^{nesg}} = pe^{-Ac_2^{nesg}(S_{22})} p_{G2}^s (S_{22}) + (1-p) e^{-Ac_2^{nesg}(S_{21})} p_{G2}^s (S_{21})$
   - $p_{B1}^s e^{-Ac_1^{nesg}} = pe^{-Ac_2^{nesg}(S_{22})} p_{B2}^s (S_{22}) + (1-p) e^{-Ac_2^{nesg}(S_{21})} p_{B2}^s (S_{21})$
   - $\theta_{G1}^{esg} = 0$
   - $p_{B1}^s \theta_{B1}^{esg} + c_1^{esg} = p_{B1}^s \theta_{B0}^{esg} + p_{G1}^s \theta_{G0}^{esg} + \psi_1^{esg}$
   - $kc_1^{esg} + (1-k)c_1^{nesg} = k\psi_1^{esg} + (1-k)\psi_1^{nesg}$.

Next, we check whether $\theta_{B1}^{nesg} > 0$. If not, then the ESG agents will own all of firm B's shares. We refer to this as the boundary equilibrium and proceed as follows.

1. Input
   - $\theta_{B0}^{esg}, \theta_{G0}^{esg}, \psi_1^{esg}, \psi_2^{esg}, \theta_{B0}^{nesg}, \theta_{G0}^{nesg}, \psi_1^{nesg}, \psi_2^{nesg}$
2. Output
   - $\theta_{B1}^{esg}, \theta_{G1}^{esg}, c_1^{esg}, \theta_{B1}^{nesg}, \theta_{G1}^{nesg}, c_1^{nesg}, p_{B1}^s, p_{G1}^s$
3. From input to output
   - $p_{B1}^s e^{-Ac_1^{esg}} = pe^{-Ac_2^{esg}(S_{22})} p_{B2}^s (S_{22}) + (1-p) e^{-Ac_2^{esg}(S_{21})} p_{B2}^s (S_{21})$
   - $p_{G1}^s e^{-Ac_1^{nesg}} = pe^{-Ac_2^{nesg}(S_{22})} p_{G2}^s (S_{22}) + (1-p) e^{-Ac_2^{nesg}(S_{21})} p_{G2}^s (S_{21})$
   - $\theta_{G1}^{esg} = 0$
   - $\theta_{B1}^{nesg} = 0$
   - $p_{B1}^s \theta_{B1}^{esg} + c_1^{esg} = p_{B1}^s \theta_{B0}^{esg} + p_{G1}^s \theta_{G0}^{esg} + \psi_1^{esg}$
   - $kc_1^{esg} + (1-k)c_1^{nesg} = k\psi_1^{esg} + (1-k)\psi_1^{nesg}$.

Voting outcome and technology adoption decision.

In order to determine the technology adoption decision on the equilibrium path, we first solve the above equations and determine whether it is the interior or boundary equilibrium at $t = 1$. Next, if it is the boundary equilibrium, then the ESG manager is elected and the technology will be adopted if available. If the equilibrium is interior, we compute $k\theta_{B1}^{esg}$. If $k\theta_{B1}^{esg} > (<)\frac{1}{2}$, then the ESG manager is elected (not elected) and the technology will (not) be adopted if available.

IA.3 Additional Results for Homogeneous Endowments

IA.3.1 Boycott equilibrium

Figure IA.1 plots the share prices as functions of the fraction k of ESG agents at $t = 1$ on the left panel and in state S_{22} on the right panel, and Figure IA.2 plots the price ratios at $t = 1$ and in state S_{22}. Similar to the Exit equilibrium in Section 5.2.1, there are two thresholds, one for shifting the share prices away from the Benchmark equilibrium and one for the brown firm manager to adopt the green technology.

The share prices to the left of $\bar{k}$ are identical to share prices in the Benchmark equilibrium with the ratio of brown to green share prices being $\frac{1}{1+\tau} \approx 0.909$. As the fraction of ESG agents crosses $\bar{k}$, the Boycott strategy starts to affect the share prices, where the green (brown) share price becomes increasing (decreasing) in the number of ESG agents and the ratio of brown share price to green share price is decreasing in k.

To find out the value of $\bar{k}$, we apply a similar argument as in the Exit case. Suppose k approaches $\bar{k}$ from the left. As discussed earlier, ESG agents have no preference towards green shares under Boycott and the returns on the two types of shares must be equal. We may assume agents arrive at S_{32} holding their endowed shares. Therefore, ESG agents in aggregate will exchange $\bar{k}D_{B3}$ units of brown goods for $\bar{k}p_{B3}^c(S_{32})D_{B3}$ units of green goods. In addition, they will use the tax rebate $\bar{k}\tau p_{B3}^c(S_{32})D_{B3}$ to purchase green goods, so the total demand of green goods is $\bar{k}(1+\tau)p_{B3}^c(S_{32})D_{B3}$. The $NESG$ agents will supply $(1-\bar{k})D_{G3}$ units of green goods. Thus, we must have $\bar{k}(1+\tau)p_{B3}^c(S_{32})D_{B3} = (1-\bar{k})D_{G3}$. Since we set $D_{G3} = D_{B3} = 0.57$ and $\tau = 0.1$, we obtain that $\bar{k} = 0.5$.

Once the fraction of ESG agents reaches $\bar{\bar{k}}$, the share prices in state S_{22A} become identical to the Benchmark equilibrium with no public bad, no tax, and reduced brown firm's output. The ratio of brown share price to green share price in this region stays at $1-\eta$ in state S_{22A}.

The intuition for the behaviors of share prices and their ratios when $k < \bar{k}$ and $k > \bar{\bar{k}}$ is analogous to the Exit case. For $k \in [\bar{k}, \bar{\bar{k}}]$, i.e., state S_{22N}, the aggregate wealth of ESG agents is high enough to absorb all of the green consumption goods at S_{32}. Since the $NESG$ agents are indifferent toward both types of consumption goods, the price $p_{B3}^c(S_{32})$ of brown consumption good must be sufficiently low in order to incentivize them to consume all of the brown good. In the Boycott equilibrium, none of the agents has a preference for shares. Therefore, the two types of shares must earn the same return; otherwise, the markets for shares will not clear. In particular, this implies that in equilibrium the share prices in state

S_{22N} must satisfy

$$\frac{D_{G3}}{p^s_{G2}(S_{22N})} = \frac{p^c_{B3}(S_{32})D_{B3}}{p^s_{B2}(S_{22N})},$$

where left-hand side is the return on a green share from $t = 2$ to 3 and the right-hand side is the return on a brown share taken into account of the brown consumption good price at $t = 3$. Note that the brown consumption tax is collected by the government and thus the tax does not enter the computation of the brown share return. Given the parameters that $D_{B3} = D_{G3}$, it is clear as $p^c_{B3}(S_{32})$ becomes low, the ratio of brown share price to green share price must fall to equalize the returns, which is shown in Figure IA.2.

As every agent is indifferent towards both shares, all agents must agree on the share prices. In particular, the share prices must satisfy

$$p^s_{G2}(S_{22N}) = e^{Ac_2^{esg}(S_{22N})-A\left(\frac{D_{G3}}{k}-\delta D_{B3}\right)}D_{G3} \tag{IA.3.1}$$

$$p^s_{B2}(S_{22N}) = e^{Ac_2^{nesg}(S_{22N})-A\left(\frac{D_{B3}}{1-k}-\delta D_{B3}\right)}\frac{1}{1+\tau}D_{B3}, \tag{IA.3.2}$$

where we have used the equilibrium conditions that $c_3^{esg}(S_{32}) = \frac{D_{G3}}{k}$ and $c_3^{nesg}(S_{32}) = \frac{D_{B3}}{1-k}$. We see that an increase in k has a first-order effect on the consumption in state S_{32} but only a second-order effect on consumption in state S_{22N} through share prices and holdings. As a result, we see an increasing (decreasing) green (brown) share price in Figure IA.1 when $k \in [\bar{k}, \bar{\bar{k}}]$. Since the ESG agents hold brown shares, in equilibrium the brown share price must also satisfy

$$p^s_{B2}(S_{22N}) = e^{Ac_2^{esg}(S_{22N})-A\left(\frac{D_{G3}}{k}-\delta D_{B3}\right)}p^c_{B3}(S_{32})D_{B3}. \tag{IA.3.3}$$

Comparing equation (IA.3.2) with (IA.3.3) and using $D_{B3} = D_{G3}$, we see that a decreasing brown share price in k is a clear manifestation of cash flow effect ($p^c_{B3}(S_{32})$) dominating the discount effect (the exponential term in (IA.3.3)).

Figure IA.3 shows the utilities of ESG and $NESG$ agents at $t = 1$. Similar to the Exit case, both agents have identical utilities when $k \leq \bar{k}$ and $k > \bar{\bar{k}}$. In the middle region where $k \in [\bar{k}, \bar{\bar{k}}]$, $NESG$ agents take advantage of the lower price of brown consumption goods at the cost of ESG paying a relatively higher price on green goods while every agent suffers the public bad equally.

Table IA.1 provides three examples of equilibrium and off-equilibrium values based on the fraction of ESG agents. The intuition for these value is similar to the Exit case except for two notable differences. First, when $k = 0.54$, both the Exit and Boycott strategies affect share prices. However, the brown (green) share price in the Boycott equilibrium is lower (higher) than the Exit equilibrium.[4] Since the brown share price is the same for both equilibria after adopting the green technology, this difference shows that it is more easily to adopt the technology under the Boycott strategy as it requires a lower fraction of ESG

[4]Refer to Lemma A.10 for a detailed proof.

agents in the economy, which is a manifestation of Proposition 5.4. The second difference is that in the Exit equilibrium the price of brown consumption goods is always fixed at $\frac{1}{1+\tau}$. In the Boycott case, this price starts to decrease when $k > \bar{k}$. In Table IA.1, we see that the pre-tax price $p^c_{B3}(S_{32}) = 0.783 < \frac{1}{1+\tau}$.

IA.3.2 Voice equilibrium

Table IA.2 provides equilibrium and off-equilibrium values for three fractions of ESG agents. There are several important differences from the Exit and Boycott. First, as discussed for Figure 5, the share holdings at $t = 1$ are not same as agents' endowed shares due to the mechanism of the Voice strategy (5.19). Therefore, when $k > \bar{\bar{k}}$ (e.g., $k = 0.35$ and 0.65), the equilibrium consumption in states S_{21} and S_{22A} will no longer equal to consumption endowments as well because agents will have different wealth entering $t = 2$. Second, even though the equilibrium consumption allocations deviate from endowments at $t = 2$ when $k = 0.35$, the time-1 consumption is still identical to their endowments. This is because $NESG$ agents hold both types of shares when $k \in [\bar{\bar{k}}, \hat{k}]$ and the expected returns at $t = 1$ must be the same. Otherwise, $NESG$ agents will strictly prefer the share with a higher return. This implies that the consumption at $t = 1$ must coincide with the one in a no-trade equilibrium, which is equal to the endowments. By contrast, the time-1 consumption for $k = 0.65$ is different from endowments because the shares have different expected returns when $k > \hat{k}$. Third, a very high fraction of ESG agents may not be welfare improving as opposite to the Exit and Boycott equilibria. In Table IA.2, the highest aggregate welfare is achieved when $k = 0.35$ while the lowest is in fact attained when $k = 0.65$. This is because the price deviation from the Benchmark when $k = 0.65$ severely dampens the utilities of ESG agents. As the size of ESG agents is large, the aggregate utility loss outweighs the utility gain of the $NESG$ agents relative to the case of $k = 0.35$.

IA.4 Mixed Strategy Equilibria

So far, we have studied only the pure strategy equilibria. That is, for a given activist strategy and fraction k of ESG agents, the manager's decision in state S_{22} is certain. In this section, we demonstrate that for some values of $k > \bar{k}$, there exist one or more mixed strategy equilibria, where the brown firm manager is indifferent toward adopting and not adopting the green technology and thus randomizes the adoption decision. The probabilities of adoption are solved endogenously.

The decision problems of individual agents are identical to a pure strategy equilibrium in Section 4.2 except that the agents will have to take into account the probability q that the green technology is adopted in state S_{22}. An important feature of our model is that an endogenous aggregate uncertainty of technology adoption arises when the brown firm manager follows a mixed strategy. It represents the risk of whether or not the pollution can be avoided conditional on arrival of the green technology. That is, the uncertainty whether or not the manager will act in a socially optimal way to reduce the pollution.

The adoption probability is determined endogenously in equilibrium such that the brown firm manager is indifferent toward technology adoption, i.e., we choose q such that $p_{B2}(S_{22N}) =$

$p_{B2}(S_{22A})$. As before, we shut down other systematic risks such as output risks, which are typical exogenous in most equilibrium models. Intuitively, on one hand, when $q = 1$, the green technology is almost surely adopted. Relative to the benchmark equilibrium (Section 5.1), there will be a reduction in firm B's output due to the cost of adoption and hence a lower share price, which can be observed in Figure 2b. On the other hand, when $q = 0$, the brown firm manager will almost surely not adopt the green technology. As we learn from Section 5.2.1, when $k > \bar{k}$ the brown share price is depressed due to the preferences of ESG agents. Therefore, the equilibrium probability q strikes a balance between the cost of adopting the technology and the price dampening effect due to activism. The proof of existence is given in Section IA.1.1. We further provide numerical examples below.

IA.4.1 Numerical Examples of Endogenous Risk

We illustrate the situation of multiple equilibria and mixed strategy equilibrium using numerical examples in Table IA.3. We first observe that when k is small (large) enough, there is only a unique pure strategy equilibrium of non-adoption (adoption). For intermediate values of k, there exist multiple equilibria. In particular, when $k = 0.576$, both the pure strategies of adoption and non-adoption can be an equilibrium. Moreover, a mixed strategy equilibrium with $q = 0.95$ also exists. When $k = 0.5765$, there exist two mixed strategy equilibria with $q = 0.245$ and 0.886 in addition to a pure strategy of adoption.

We now proceed to examine the behaviors of prices and returns for the two types of shares. Let us focus on a mixed strategy equilibrium with $q = 0.886$ when $k = 0.5765$. Suppose the reality corresponds to $t = 1$ in our model. Taking into account the probabilities of technology arrival and manager's adoption decision, the expected one-period return from $t = 1$ to 2 is zero for both green and brown shares. However, brown shares have a higher expected two-period return ($t = 1$ to 3) of 3.57% versus 2.01% for green shares. As we take the green output as the numeraire at $t = 3$, this implies that brown shares earn an unconditional risk premium of 1.56% from $t = 1$ to 3. In addition, the two-period return for green shares is less risky than brown shares. Regardless of the state at $t = 3$, green shares always earn a return of 2.01% since the green output is unaffected by technology availability or manager's adoption decision. The returns on brown shares are more variable, ranging from 0.91% in state S_{33} to 7.92% in states S_{31} and S_{32}.

Next, we consider the returns conditional on technology being available (S_{22}). Both green and brown shares earn negative returns from $t = 1$ to 2 if the technology is adopted: -2.3% for green shares and -3.39% for brown. However, green shares have a positive one-period return from period 1 to 2 and brown shares have a negative one-period return from period 1 to 2 if the technology is not adopted: 10.7% for green shares and -3.39% for brown. The conditional expected return for green shares is -0.86%, i.e., a conditional risk premium of 2.54% relative to brown shares, while unconditionally they both earn zero expected one-period return. The returns on green shares range from -2.3% in state S_{22A} to 10.7% in state S_{22N} while the brown share return stays at -3.39% in both states. Hence, conditional on technology being available, green shares have a riskier return from $t = 1$ to 2 than brown shares. s a result, the relative risk ordering of green and brown shares changes depending on the horizon. Green preference induces endogenous uncertainty in the economy and makes green share riskier in the near term and brown share riskier in the longer term.

In this example, green shares are valued higher than brown shares even after accounting for emissions tax. Because of the endogenous risks in state S_{22}, the outperformance of green shares may not sustain in the long run. To see this, consider state S_{22N}. Green shares have a high one-period return from $t = 1$ to 2 followed by a low return from $t = 2$ to 3. By contrast, brown share returns are low during period 1-2 and high from period 2 to 3. This is consistent with the observation in Pástor et al. (2022) that high (low) returns on green (brown) stocks do not necessarily imply the same pattern in the future. Going forward green and brown share effects will not persist and hence value stocks may outperform growth stocks.

IA.5 Additional Results for Heterogeneous Endowments

This section provides additional numerical results for Exit, Boycott, and Voice strategies under heterogeneous endowments.

IA.5.1 Exit

Under Exit, we assume that the ESG agents do not invest in the brown firm at $t = 2$,

$$\theta_{B2}^{esg} = 0. \tag{IA.5.1}$$

We examine an equilibrium where the ESG agents are willing to restrict their choices with (IA.5.1). Same as Section 5.2.1, the pre-tax price of the brown consumption goods in states S_{31} and S_{32} is $\frac{1}{1+\tau}$ and in state S_{33} is 1.

We characterize the Exit equilibrium in the figures below and in particular examine equilibrium outcomes when an individual ESG agent is less wealthy than an individual $NESG$ agents. We fix the fraction of ESG agents to be $k = 0.65$ so that it is possible to have the green technology adoption in equilibrium when ESG agents are sufficiently wealthy.[5] Similar to Section 5.2.1, the parameters are calibrated such that both shares have zero net returns in the Benchmark.

Figure IA.4 plots the green and brown share prices with respect to the individual wealth ratio λ at $t = 1$ on the left panel and in state S_{22} on the right panel. Similar to the homogeneous case in Figure 2, there are also two critical thresholds for the individual wealth ratio. The first threshold, $\bar{\lambda}$, determines when the Exit strategy begins to affect the equilibrium share prices. When $\lambda \leq \bar{\lambda}$, each individual ESG agent is substantially poorer than a $NESG$ agent. Since we have fixed the fraction k of ESG agents, there is a one-to-one relation between individual wealth and the aggregate wealth of each type. This implies that the aggregate wealth of ESG agents is low when $\lambda \leq \bar{\lambda}$. However, such low aggregate wealth is not enough to absorb all the green shares available. As discussed for Figure 2, $NESG$ agents will also hold green shares, which forces both shares to earn the same return.

Once the ESG agents become wealthy enough, i.e., λ starts to rise above $\bar{\lambda}$, the Exit strategy will affect the share prices as the aggregate wealth of ESG agents is more than enough to buy all of the green shares. Similar to Figure 2, the green (brown) share price

[5] If we choose k such that it is lower than $\bar{\bar{k}}$ in the corresponding homogeneous case, then the green technology will never be adopted for any $\lambda \in [0, 1]$.

is upward (downward) sloping when λ is between the two thresholds. The reason is that in order to incentivize ESG agents to clear the market for the green shares, the interest rate must be low enough. When λ grows, the ESG agents will have more wealth to spend. Such incentive needs to be stronger. Since the interest rate is directly linked to the green share return, this leads to a higher price for the green shares. For the brown shares, however, the no-short selling constraint prohibits the $NESG$ agents from taking advantage of the high green share price by short selling them to buy more consumption goods. The return on the brown shares must be high enough to incentivize the $NESG$ agents to hold all of the brown shares and to not borrow. This induces a lower price for the brown shares.

As the ESG agents become wealthier when $\lambda > \bar{\lambda}$, the brown share price will be lower. Once the brown share price is depressed sufficiently low, the brown firm's manager will adopt the green technology according to the rule (4.4). After the adoption, two firms are essentially identical in terms of ESG agents' preferences, which results in constant prices with respect to λ.

Figure IA.5 shows the price ratios at $t = 1$ and in state S_{22}. Similar to Figure 3, the ratio stays at $\frac{1}{1+\tau} \approx 0.909$ when $\lambda \leq \bar{\lambda}$ and becomes flat again when $\lambda > \bar{\bar{\lambda}}$. In particular, in state S_{22A}, the ratio is $1 - \eta = 0.85$ as seen in plot on the right panel. The price ratio decrease with respect to λ when $\lambda \in [\bar{\lambda}, \bar{\bar{\lambda}}]$ because the green share price increases and brown share price decreases in this region as discussed above. In addition, the price ratio in this region can be lower than the ratio when $\lambda > \bar{\bar{\lambda}}$. Again, the manager does not adopt the technology by looking at the relative price. Instead, the decision is made based on the price level of the brown shares.

Figure IA.6 plot the individual utility levels for both types of agents at $t = 1$. Unlike Figure 4 where all agents have the same utility in the first region, in the current scenario an individual ESG agent has a much lower utility than a $NESG$ agent when $\lambda \leq \bar{\lambda}$. This is because an individual ESG agent has very little endowment wealth when λ is small, leading to low equilibrium consumption, which in turn results in a low utility level. Another distinction is that in the middle region the ESG ($NESG$) utility keeps increasing (decreasing) whereas it is the reverse in the homogeneous case. While the ESG agents have to pay a high price for the green shares and $NESG$ agents can enjoy the cheaper brown shares, the wealth effect dominates in the sense that the ESG agents become wealthier as λ gets larger and $NESG$ agents becomes poorer due to the market clearing conditions. The wealth effect continues dominating when $\lambda > \bar{\bar{\lambda}}$, which is the third difference from the homogeneous case. Once $\lambda = 1$, the two utility levels coincide. Finally, we also provide equilibrium and off-equilibrium values for three examples of individual wealth ratios in Table IA.4.

IA.5.2 Boycott

Next, we consider a case where the ESG agents do not consume the consumption good from the brown firm at $t = 3$ if the brown firm did not adopt the green technology,

$$c_{B3}^{esg}(S_{32}) = 0. \tag{IA.5.2}$$

We investigate an equilibrium where the ESG agents are willing to sacrifice their choices with (IA.5.2).

We use the same set of parameters as in the Exit equilibrium above. Figure IA.7 plots the share prices as functions of the individual wealth ratio λ at $t = 1$ and in state S_{22}. Just like the Exit equilibrium above, there are two thresholds of λ, one for price impact and the other for technology adoption. Similar to the homogeneous case, both thresholds are lower than those in the corresponding Exit equilibrium, leading to the conclusion that Boycott is more effective, in terms of requiring a lower individual wealth ratio, under the heterogeneous wealth case as well.

The intuition for the relation between share prices and individual wealth ratio is as follows. When individual ESG agents are sufficiently poorer than $NESG$ agents ($\lambda \leq \bar{\lambda}$), the aggregate wealth of ESG agents is also low because the ESG population is fixed. This implies that ESG agents are unable to absorb all the green consumption goods at $t = 3$. Therefore, the price of brown consumption good at $t = 3$ will not be affected by the Boycott strategy, nor will share prices be.

As the individual wealth ratio reaches beyond $\bar{\lambda}$, the Boycott strategy will impact the share prices since the aggregate wealth of ESG agents is sufficiently high. Unlike the Exit case where the price impact operates through a high return on brown shares, in the Boycott equilibrium both green and brown shares earn the same return regardless of λ. Instead, the Boycott strategy will dampen the brown consumption good price $p^c_{B3}(S_{32})$ in state S_{32} in order to incentivize $NESG$ agents to consume all the brown goods. Therefore, the relative price of brown shares decreases as seen in Figure IA.8.

Recall that the share prices must satisfy

$$p^s_{G2}(S_{22N}) = e^{Ac_2^{esg}(S_{22N}) - A\left(\frac{D_{G3}}{k} - \delta D_{B3}\right)} D_{G3}$$

$$p^s_{B2}(S_{22N}) = e^{Ac_2^{nesg}(S_{22N}) - A\left(\frac{D_{B3}}{1-k} - \delta D_{B3}\right)} \frac{1}{1+\tau} D_{B3}.$$

Since we have fixed the fraction k of ESG agents, the individual consumption at $t = 3$ is also fixed when $\lambda \in [\bar{\lambda}, \bar{\bar{\lambda}}]$ because all of the green (brown) consumption goods are consumed by ESG ($NESG$) agents. As λ increases, individual ESG agents become wealthier, meaning that $c_2^{esg}(S_{22N})$ will become larger than before and $c_2^{nesg}(S_{22N})$ becomes smaller due to market clearing. This implies that the green (brown) share price increases (decreases) with $\lambda \in [\bar{\lambda}, \bar{\bar{\lambda}}]$. In this case, only the discount effect is in action. By contrast, in the Exit equilibrium, both the cash flow and discount effects are present, and the cash flow effect dominates.

When the individual wealth ratio is larger than $\bar{\bar{\lambda}}$, the brown share price will be sufficiently low if the green technology is not adopted in state S_{22N}. The brown firm's manager will then have an incentive to adopt the technology to boost the share price at $t = 2$. Therefore, share prices will remain constant for any $\lambda > \bar{\bar{\lambda}}$. The ratio of share prices at S_{22} will stay at $1 - \eta = 0.85$ as shown in Figure IA.8.

Figure IA.9 plots individual utility levels at $t = 1$. Similar to Figure IA.6, ESG agents have much lower utilities when $\lambda \leq \bar{\lambda}$ because of lower wealth. As λ increases, the utility for ESG ($NESG$) agents keeps increasing (decreasing). Two utility levels coincide when $\lambda = 1$, i.e., when they have the same initial wealth. Finally, we also provide equilibrium and off-equilibrium values for three examples of individual wealth ratios in Table IA.5.

IA.5.3 Voice

Finally, we consider Voice strategy. In particular, we consider a scenario in which the ESG agents all-in the shares of the brown firm (or abstain from investing in the green firm) at $t = 1$, and contingent on that the aggregate shares of ESG agents for the brown firm is the majority or not, the ESG agents replace the incumbent manager of the brown with the ESG type, who will adopt the green technology whenever it is feasible,

$$\theta_{G1}^{esg} = 0 \text{ and } S_{22} = S_{22A} \text{ if } k\theta_{B1}^{esg} > 0.5. \tag{IA.5.3}$$

We examine an equilibrium where the ESG agents engage in a manner of (IA.5.3). The same set of parameters as before is used in the figures below.

Figure IA.10 shows the relationship between share prices and individual wealth ratio λ at $t = 1$ and in state S_{22}. Similar to the homogeneous case, there are two thresholds, one for technology adoption ($\bar{\bar{\lambda}}$) and the other for the ESG agents to hold all of the brown shares ($\hat{\lambda}$). When the wealth ratio is less than $\bar{\lambda}$, the share prices are identical to those in the Benchmark equilibrium. When the ESG agents are sufficiently wealthy in aggregate ($\lambda > \bar{\lambda}$), they will hold more than 50% of the brown shares and the ESG manager will be elected for the brown firm. As a result, the green technology will be adopted when available. In both of these two regions, the ratios of share prices are constant in λ, as shown in Figure IA.11.

When the aggregate wealth of ESG agents is large enough, they will able to purchase all of the brown shares ($\lambda > \bar{\bar{\lambda}}$). Compared with the situation when $\lambda \leq \hat{\lambda}$, there is now a downward price pressure at $t = 1$ for the green shares as ESG agents in aggregate offload more endowed green shares. Furthermore, the return on the green shares must be high enough to incentivize the $NESG$ agents, who are indifferent towards the types of shares, to hold only the green shares. The ratio of share prices also increases in λ when $\lambda > \hat{\lambda}$.

Figure IA.12 plots the individual utilities at $t = 1$. Similar to Figures IA.6 and IA.9, the utility for an ESG agent rises in λ due to increases in wealth. However, unlike Exit and Boycott, when $\lambda = 1$, the two utilities do not coincide. This is because for the particular fraction of ESG agents that we chose ($k = 0.65$), an individual $NESG$ agent has a higher utility than an ESG agent even when they have identical endowments, which is shown in Figure 6. Finally, we also provide equilibrium and off-equilibrium values for three examples of individual wealth ratios in Table IA.6.

IA.6 Additional Results for Heterogeneous Firm Sizes

This section gives two examples of heterogeneous firm sizes, one for larger firm G and the other for larger firm B. As in Section 6.2, we fix the total output size to be $D_{B3}+D_{G3} = 1.14$ and vary the ratio of D_{G3} to D_{B3}.

IA.6.1 Firm G is larger

In the first example, we let firm G be the larger part of the economy. We set the firm size ratio $\zeta = 1.5$, which implies the firm G's dividend is $D_{G3} = 0.684$, and firm B's dividend is $D_{B3} = 0.456$.

Exit

As before, we first analyze the Exit strategy case. Figure IA.13 plots the green and brown share prices at $t = 1$ and in state S_{22}. Comparing these with Figure 2, there are two notable differences. One is that the gap between the green and brown share prices is much larger than the previous case with equal firm sizes. This is because the share price is defined to be the discounted value of dividend payout. With a higher dividend from the green firm, the green share price must be larger than before. The second difference is that both thresholds $\bar{k}$ and $\bar{\bar{k}}$ are also much larger compared to the previous case. Since agents have equal endowments, the total supply of shares of each firm is 1. Since the gap in share prices is increased, a higher aggregate wealth of ESG agents will be needed to absorb all the green shares. Thus, we observe higher threshold levels. Apart from these differences, the behaviors of share prices with respect to k follow the same intuition as for Figure 2.

Figure IA.14 shows the price ration of brown and green shares. The ratio, either at $t = 1$ or in state S_{22}, is much smaller than the one in Figure 3 because $D_{B3} < D_{G3}$. Indeed, the price ratio after the green technology adoption at $t = 2$ (in state S_{22A}) is $\frac{(1-\eta)D_{B3}}{D_{G3}} \approx 0.567$ as shown in Figure IA.14b.

Finally, for Exit we plot the individual utility levels at $t = 1$ in Figure IA.15. We notice that in the region where the Exit strategy affects share prices but the green technology is not adopted (i.e., $k \in [\bar{k}, \bar{\bar{k}}]$), the ESG agents tend to have higher utility and $NESG$ agents tend to have lower utility compared with the same region in Figure 4. For example, this comparison can be seen by comparing utility levels at the second threshold $\bar{\bar{k}}$ in each case. This is because the ESG agents are the sole claimants to the green firm's dividend, which is the larger part of the economy, while the $NESG$ agents only claim the brown firm's dividend. With the given parameters, an individual ESG agent in this example has more to spend on consumption than a $NESG$ agent at $t = 3$ compared to the case of equal firm sizes. Therefore, the ESG agents will consume more at $t = 3$ and have a higher utility level at the second threshold $\bar{\bar{k}}$.

Boycott

We next move to the Boycott strategy. Figures IA.16 and IA.17 plot share prices and price ratio, respectively, at $t = 1$ and in state S_{22}. As with the scenario of equal firm sizes, both of the thresholds $\bar{k}$ and $\bar{\bar{k}}$ are lower than the Exit case due to Proposition 5.4. The intuition for these plots is similar to Figures IA.1 and IA.2. The larger price gap is again because of the unequal firm sizes as discussed for the Exit case above.

Figure IA.18 shows the individual utilities at $t = 1$. Similar to the Exit case, all agents have identical utilities when $k \leq \bar{k}$ and $k > \bar{\bar{k}}$. In the region where $k \in [\bar{k}, \bar{\bar{k}}]$, ESG agents tend to have higher and $NESG$ agents tend to have lower utilities compared to Figure IA.3 for a similar reason discussed for Figure IA.15.

Voice

Figures IA.19 and IA.20 plot share prices and utilities for the Voice strategy. We notice that given this set of parameters the Voice strategy is the most effective one in adopting the green technology as it requires the least fraction of ESG agents. The intuition for these plots follow similarly from Section 5.2.3 and thus we omit the discussions here.

IA.6.2 Firm B is larger

In the second example, we let firm B be the larger part of the economy. We set the firm size ratio $\zeta = 0.25$, which implies the firm G's dividend is $D_{G3} = 0.228$, and firm B's dividend is $D_{B3} = 0.912$.

Exit

Figure IA.21 plots the share prices at $t = 1$ and in state S_{22} for the Exit case. There are two stark differences from Figure IA.13 where $D_{G3} > D_{B3}$. The first one is that the brown share price is much higher than the green share price. This is because the brown tree becomes the larger part of the economy and the larger output results in a higher price. The behavior of each share price with respect to k, though, is similar to before. The intuition for such behavior is identical to Figure 2. The second difference is that the two thresholds, $\bar{k}$ and $\bar{\bar{k}}$, are much lower than those in Figure IA.13. The reason is that as the green share price is low, the aggregate wealth of ESG agents required to absorb all green shares will also be low. Since all agents have identical endowments, this results in a lower fraction of ESG agents to cause price deviation from the Benchmark, i.e., lower $\bar{k}$, and subsequently a lower technology adoption threshold $\bar{\bar{k}}$.

Figure IA.22 shows the price ratios at $t = 1$ and in state S_{22}. As discussed above, the brown share price is much higher than the green share price, resulting in the price ratio larger than 1. The ratio stays constant with respect to k when $k \leq \bar{k}$ and $k > \bar{\bar{k}}$. In particular, the ratio is $\frac{D_{B3}}{(1+\tau)D_{G3}} \approx 3.636$ when the green technology is available but not adopted (state S_{22N}) and becomes $\frac{(1-\eta)D_{B3}}{D_{G3}} = 3.4$ after the technology is adopted (state S_{22A}) in Figure IA.22b.

The last plot of the Exit case (Figure IA.23) shows the individual utilities. We notice that in the region where the share prices deviate from the Benchmark but the green technology is not adopted, the ESG agents have lower utilities than the one in Figure IA.15. The reason is that the ESG agents are the sole claimants to the green firm's output, which is the smaller part of the economy. The ESG agents thus have less to spend at $t = 3$ on consumption than the $NESG$ agents. Therefore, ESG agents will consume less at $t = 3$ and have a lower utility level at the second threshold $\bar{\bar{k}}$ compared to Figure IA.15.

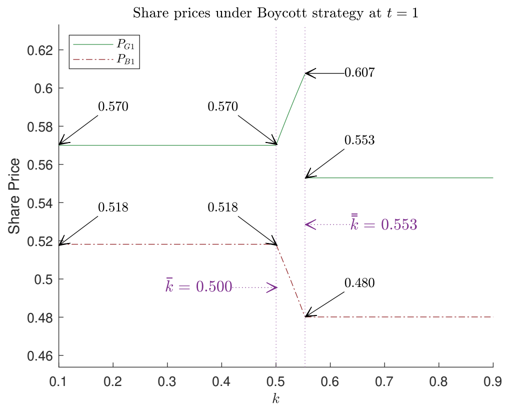
Boycott

Figures IA.24 and IA.25 plot share prices and price ratios, respectively. Similar to Section IA.6.1, both thresholds in the Boycott equilibrium are lower than the Exit case. The brown share price is still larger than the green share price due to a higher dividend from the brown firm.

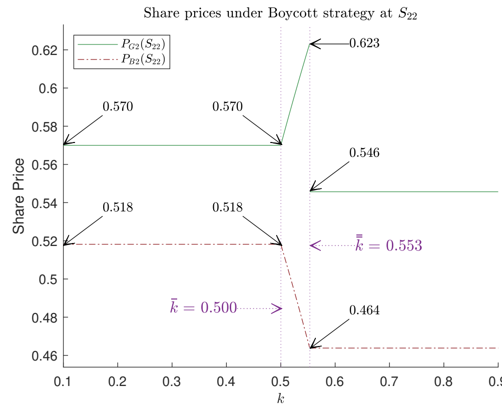
Figure IA.26 shows individual utilities at $t = 1$. The ESG agents have lower utility in the region between the two thresholds because they only consume the green consumption good, which is produced from the green output. As the green output is lower than the brown output, the ESG agents will consume less than the $NESG$ agents, resulting in a lower utility for ESG agents.

Voice

Finally, we consider the Voice strategy. The intuition for Figures IA.27 and IA.28 is similar to Section 5.2.3. Comparing to the Voice case in Section IA.6.1, one important difference is that both thresholds here are much higher. The reason is that when the size of the brown firm is sufficiently large, we would also need a large fraction of ESG agents in order to hold the majority of brown shares. This shows that Voice need not dominate Exit or Boycott as stated in Proposition 5.6.

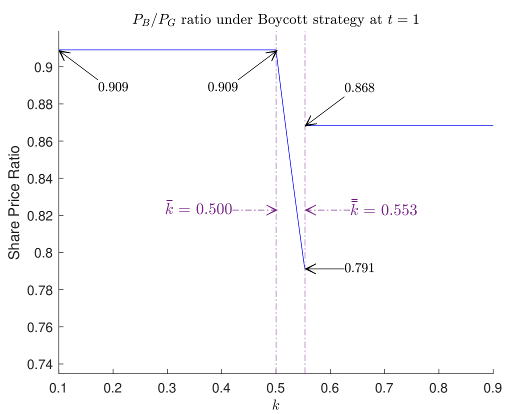


(a) Share prices at $t = 1$

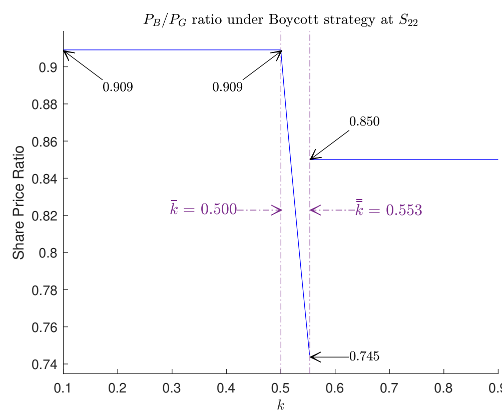


(b) Share prices at S_{22}

Figure IA.1: Boycott - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1.



(a) Share price ratio at $t = 1$



(b) Share price ratio at S_{22}

Figure IA.2: Boycott - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1.

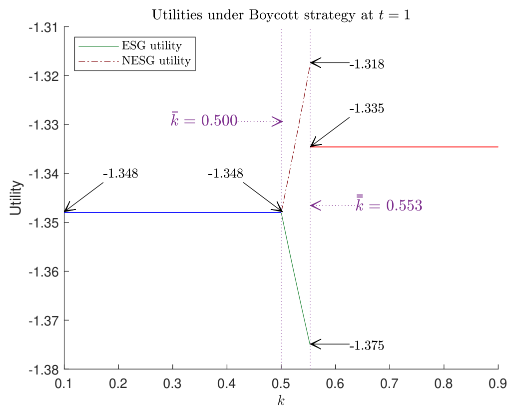
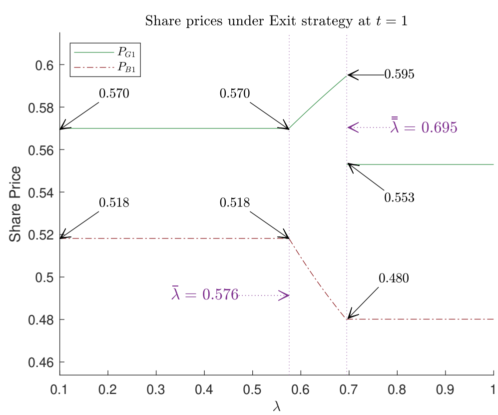
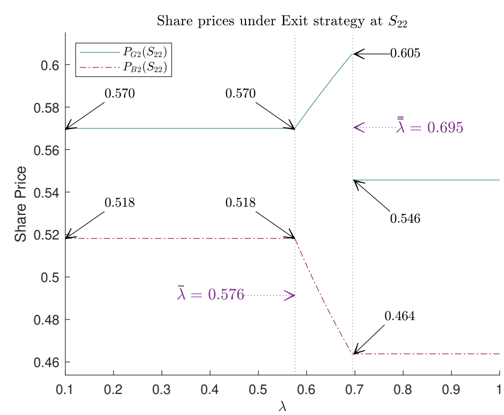


Figure IA.3: Boycott - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{k}$. The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k \in [\bar{k}, \bar{\bar{k}}]$. The red line is the utility level for both ESG and $NESG$ agents when $k > \bar{\bar{k}}$. Parameters are from Table 1.

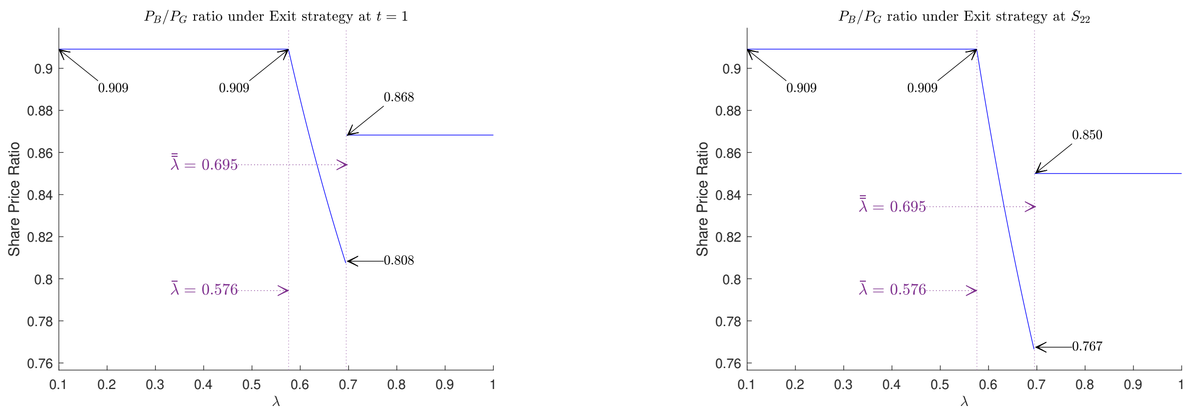


(a) Share prices at $t = 1$



(b) Share prices at S_{22}

Figure IA.4: Exit - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of λ, beyond which the Exit strategy either has a price impact ($\bar{\lambda}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{\lambda}}$). Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.



(a) Share price ratio at $t = 1$

(b) Share price ratio at S_{22}

Figure IA.5: Exit - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The purple dotted lines denote the threshold level of λ, beyond which the Exit strategy either has a price impact ($\bar{\lambda}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{\lambda}}$). Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.

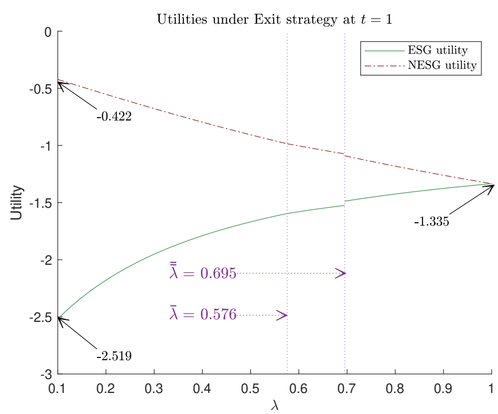
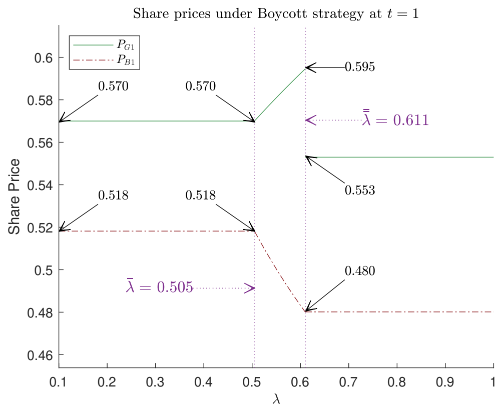
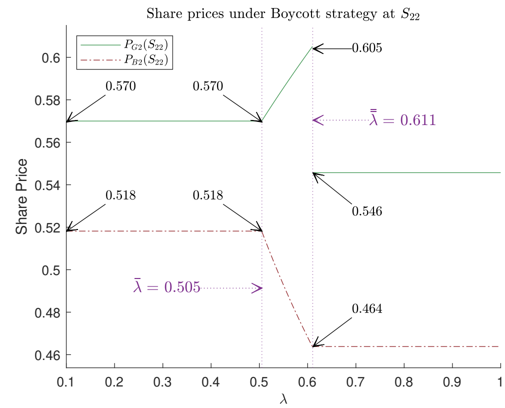


Figure IA.6: Exit - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The purple dotted lines denote the threshold level of λ, beyond which the Exit strategy either has a price impact ($\bar{\lambda}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{\lambda}}$). The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.

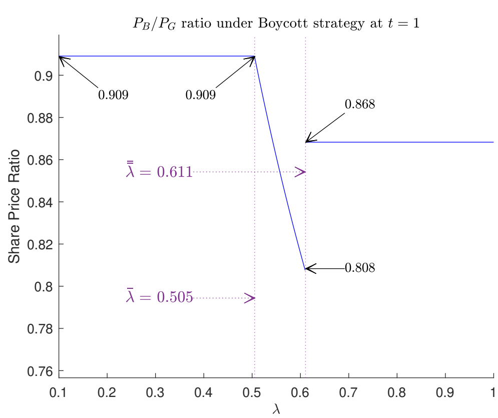


(a) Share prices at $t = 1$

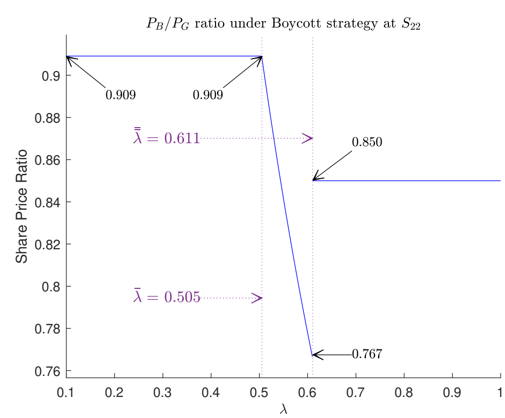


(b) Share prices at S_{22}

Figure IA.7: Boycott - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of λ, beyond which the Boycott strategy either has a price impact ($\bar{\lambda}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{\lambda}}$). Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.



(a) Share price ratio at $t = 1$



(b) Share price ratio at S_{22}

Figure IA.8: Boycott - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The purple dotted lines denote the threshold level of λ, beyond which the Boycott strategy either has a price impact ($\bar{\lambda}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{\lambda}}$). Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.

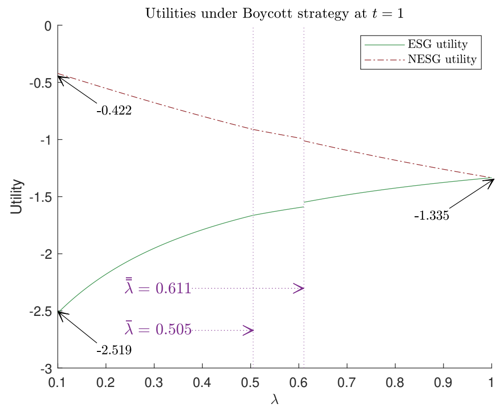
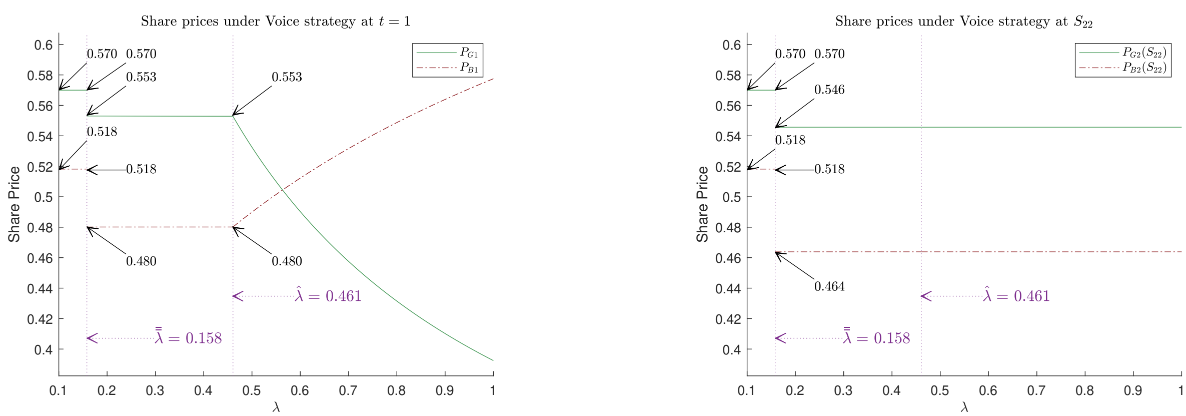


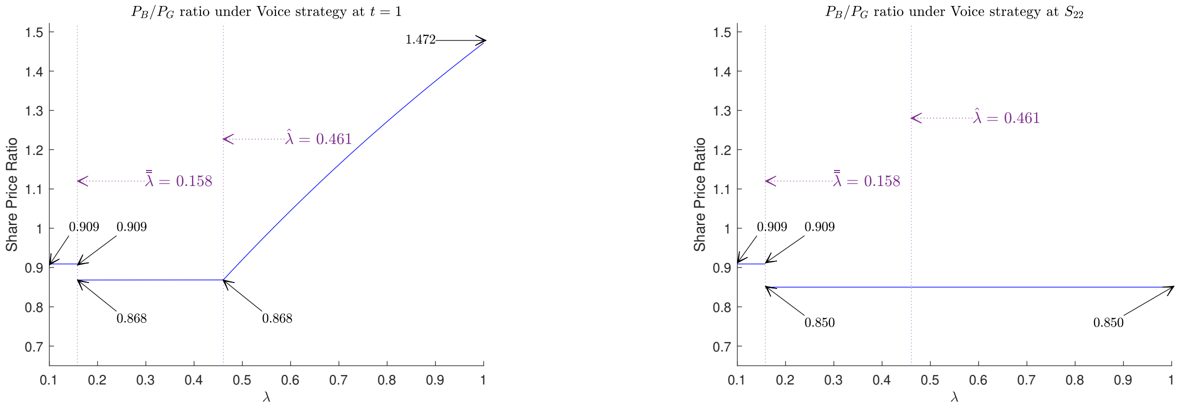
Figure IA.9: Boycott - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The purple dotted lines denote the threshold level of λ, beyond which the Boycott strategy either has a price impact ($\bar{\lambda}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{\lambda}}$). The red and blue lines indicate the utility levels for ESG and $NESG$ agents, respectively. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.



(a) Share prices at $t = 1$

(b) Share prices at S_{22}

Figure IA.10: Voice - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of λ, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{\lambda}}$) or all of the firm B's shares ($\hat{\lambda}$). Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.



(a) Share price ratio at $t = 1$ (b) Share price ratio at S_{22}

Figure IA.11: Voice - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The purple dotted lines denote the threshold level of λ, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{\lambda}}$) or all of the firm B's shares ($\hat{\lambda}$). Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.

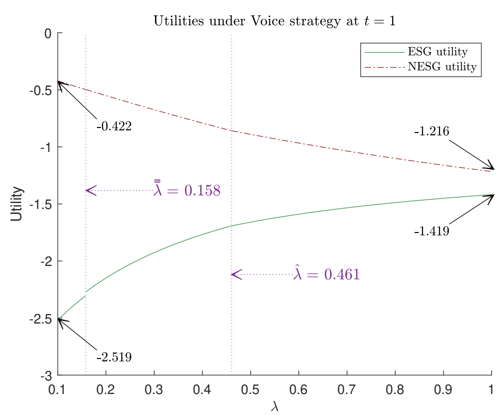
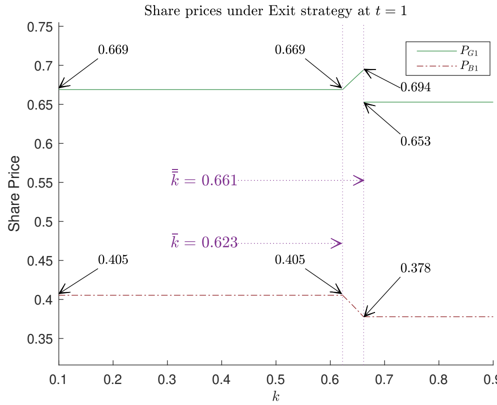
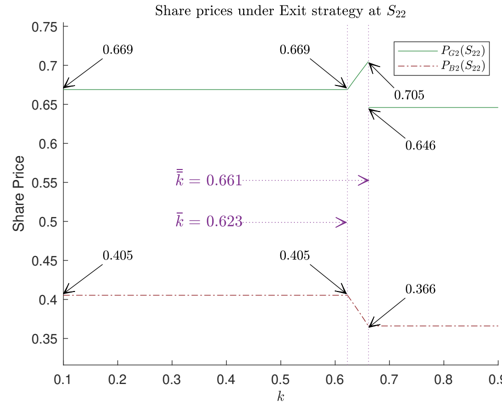


Figure IA.12: Voice - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the individual wealth ratio λ when the fraction of ESG agents is $k = 0.65$. The purple dotted lines denote the threshold level of λ, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{\lambda}}$) or all of the firm B's shares ($\hat{\lambda}$). The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1.

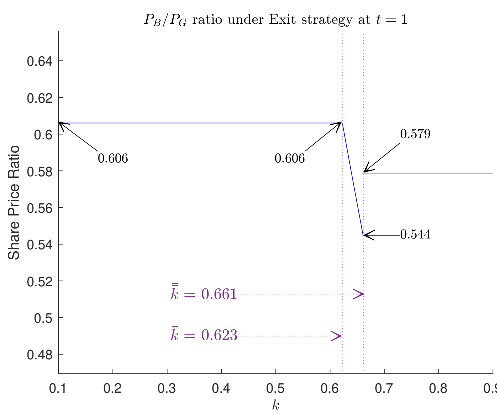


(a) Share prices at $t = 1$

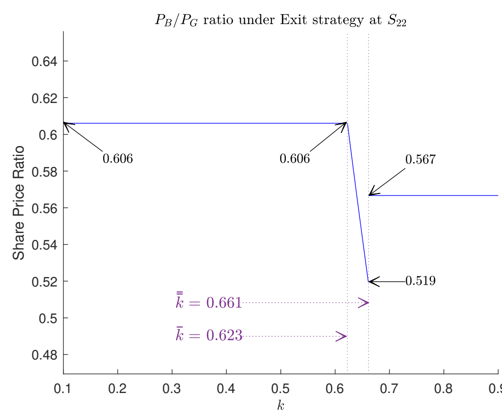


(b) Share prices at S_{22}

Figure IA.13: Exit - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm G is larger than firm B. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1 except that the output ratio is $\zeta = 1.5$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share price ratio at $t = 1$



(b) Share price ratio at S_{22}

Figure IA.14: Exit - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm G is larger than firm B. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1 except that the output ratio is $\zeta = 1.5$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.

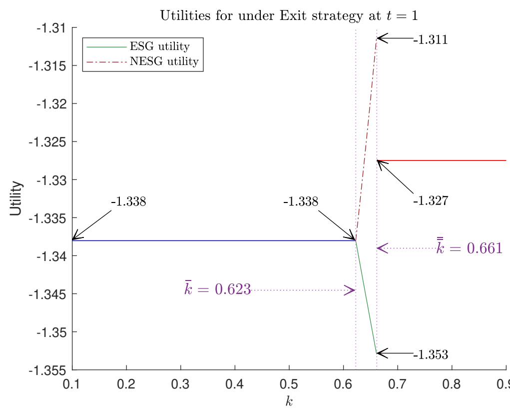
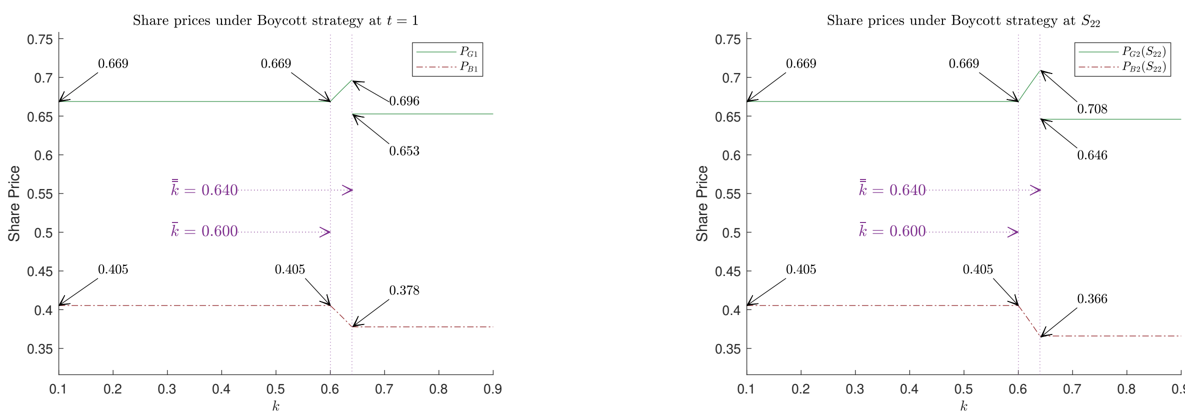


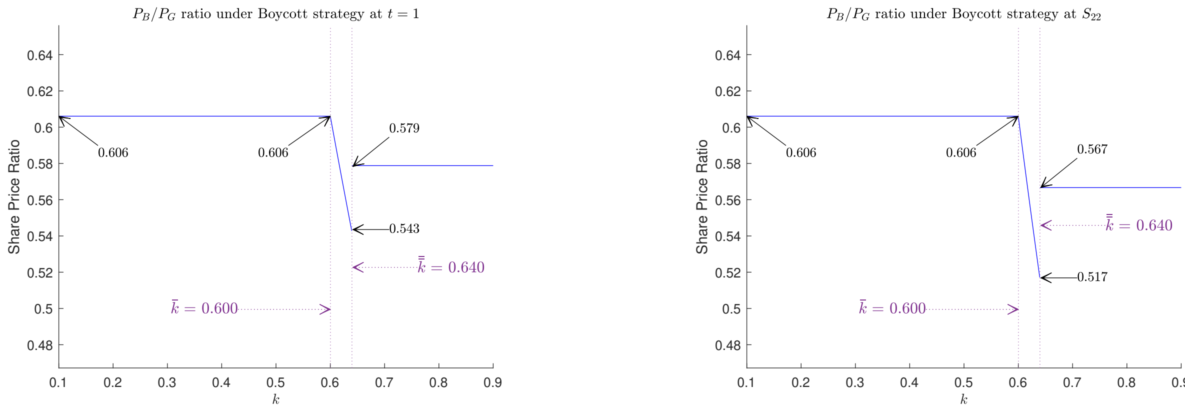
Figure IA.15: Exit - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents when firm G is larger than firm B. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces e firm B's manager to adopt the green technology ($\bar{\bar{k}}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{k}$. The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k \in [\bar{k}, \bar{\bar{k}}]$. The red line is the utility level for both ESG and $NESG$ agents when $k > \bar{\bar{k}}$. Parameters are from Table 1 except that the output ratio is $\zeta = 1.5$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share prices at $t = 1$

(b) Share prices at S_{22}

Figure IA.16: Boycott - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm G is larger than firm B. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1 except that the output ratio is $\zeta = 1.5$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share price ratio at $t = 1$ (b) Share price ratio at S_{22}

Figure IA.17: Boycott - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm G is larger than firm B. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1 except that the output ratio is $\zeta = 1.5$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.

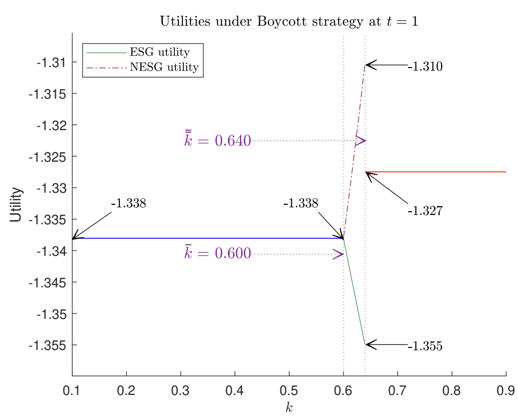
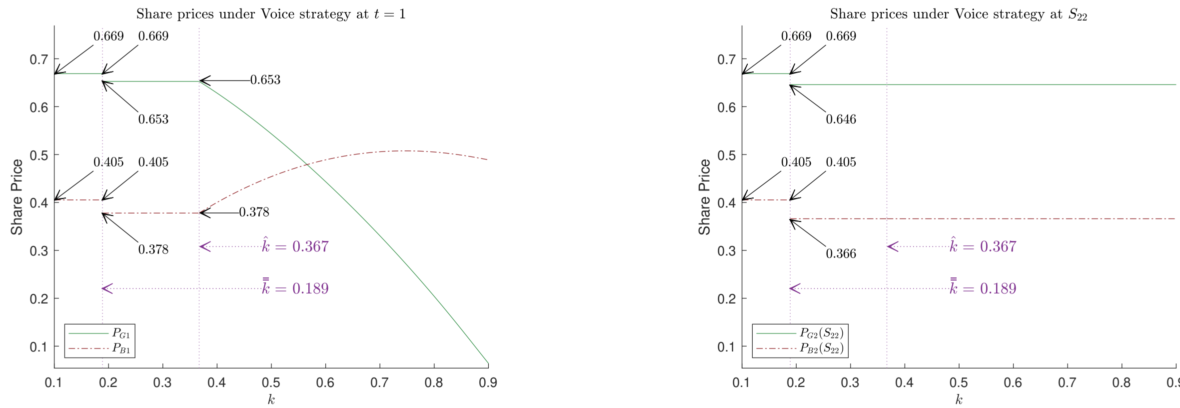


Figure IA.18: Boycott - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents when firm G is larger than firm B. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{k}$. The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k \in [\bar{k}, \bar{\bar{k}}]$. The red line is the utility level for both ESG and $NESG$ agents when $k > \bar{\bar{k}}$. Parameters are from Table 1 except that the output ratio is $\zeta = 1.5$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share prices at $t = 1$ (b) Share prices at S_{22}

Figure IA.19: Voice - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm G is larger than firm B. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{k}}$) or all of the firm B's shares ($\hat{k}$). Parameters are from Table 1 except that the output ratio is $\zeta = 1.5$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.

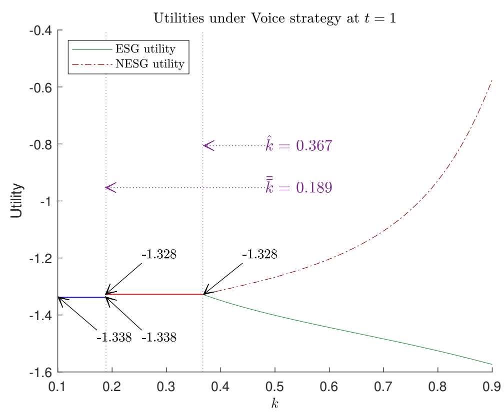
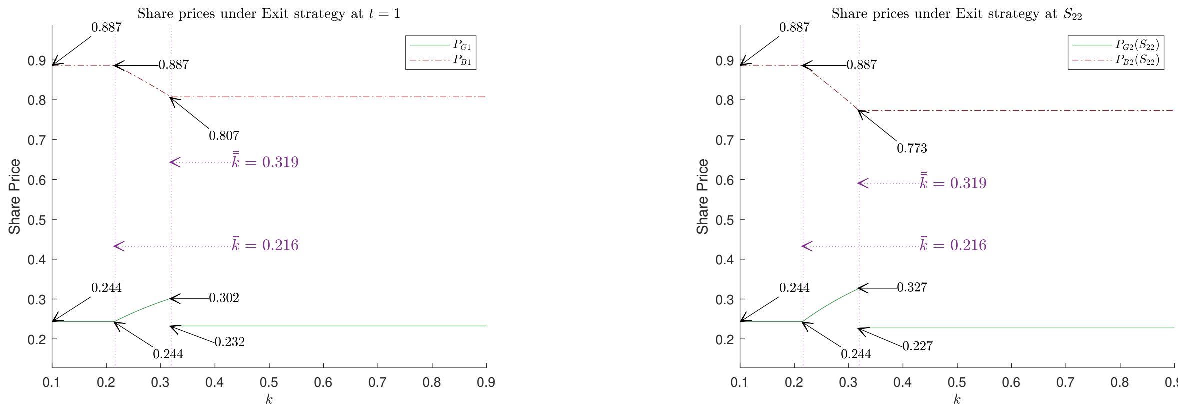


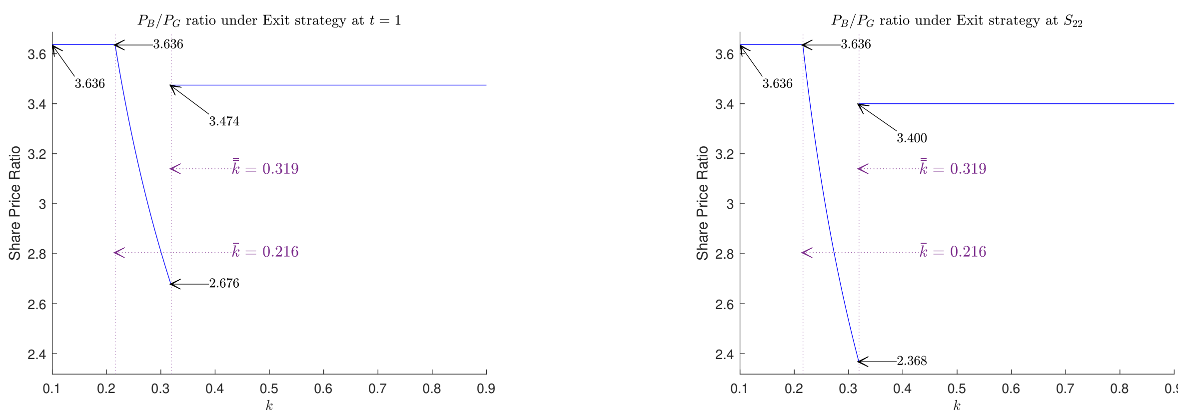
Figure IA.20: Voice - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents when firm G is larger than firm B. The purple dashed lines denote the threshold level of k, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{k}}$) or all of the firm B's shares ($\hat{k}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{\bar{k}}$. The red line is the utility level for both ESG and $NESG$ agents when $k \in [\bar{\bar{k}}, \hat{k}]$. The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k > \hat{k}$. Parameters are from Table 1 except that the output ratio is $\zeta = 1.5$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share prices at $t = 1$

(b) Share prices at S_{22}

Figure IA.21: Exit - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm B is larger than firm G. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1 except that the output ratio is $\zeta = 0.25$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share price ratio at $t = 1$

(b) Share price ratio at S_{22}

Figure IA.22: Exit - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm B is larger than firm G. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1 except that the output ratio is $\zeta = 0.25$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.

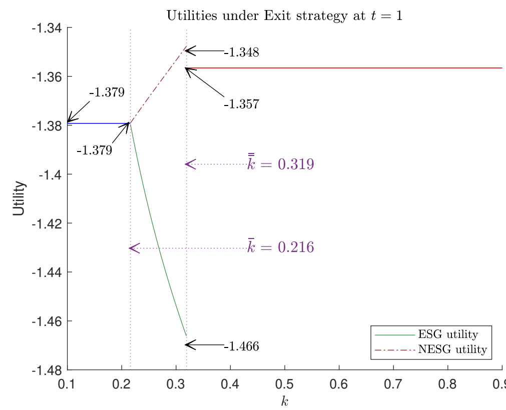
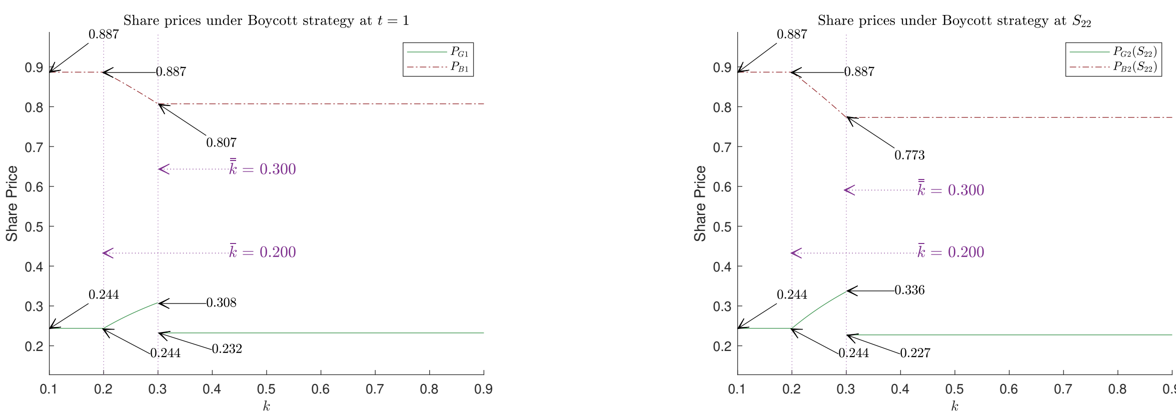


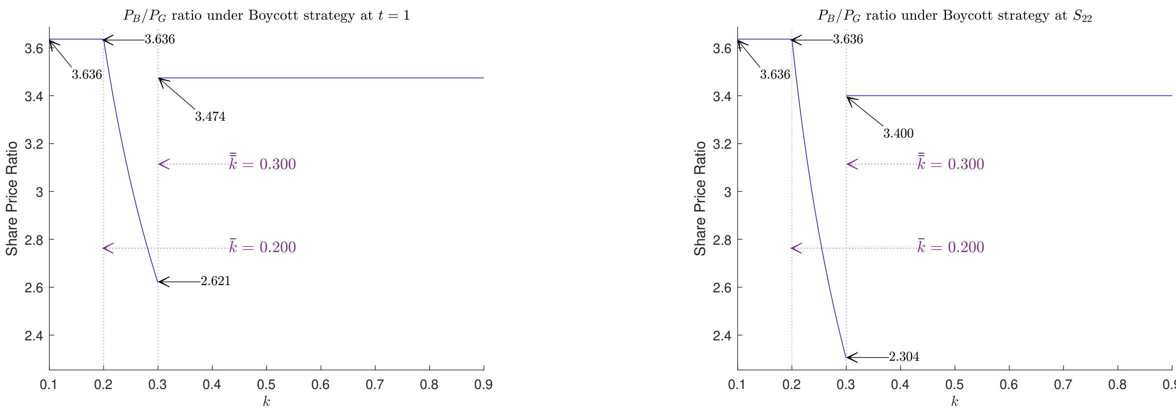
Figure IA.23: Exit - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents when firm B is larger than firm G. The purple dotted lines denote the threshold level of k, beyond which the Exit strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{k}$. The green and brown dash-dot lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k \in [\bar{k}, \bar{\bar{k}}]$. The red line is the utility level for both ESG and $NESG$ agents when $k > \bar{\bar{k}}$. Parameters are from Table 1 except that the output ratio is $\zeta = 0.25$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share prices at $t = 1$

(b) Share prices at S_{22}

Figure IA.24: Boycott - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm B is larger than firm G. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1 except that the output ratio is $\zeta = 0.25$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share price ratio at $t = 1$ (b) Share price ratio at S_{22}

Figure IA.25: Boycott - share price ratio. This figure plots ratios of share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm B is larger than firm G. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). Parameters are from Table 1 except that the output ratio is $\zeta = 0.25$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.

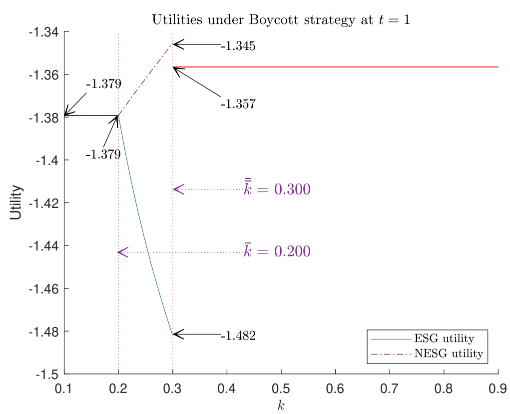
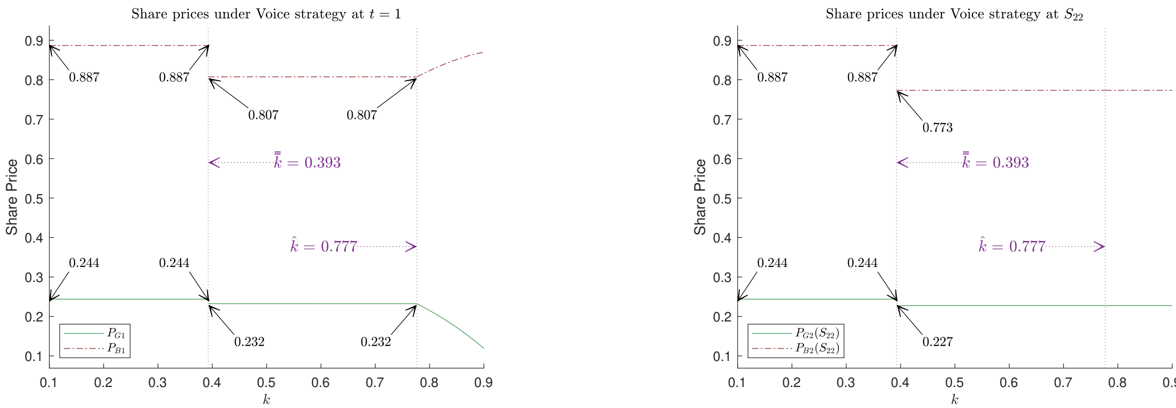


Figure IA.26: Boycott - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents when firm B is larger than firm G. The purple dotted lines denote the threshold level of k, beyond which the Boycott strategy either has a price impact ($\bar{k}$) or induces firm B's manager to adopt the green technology ($\bar{\bar{k}}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{k}$. The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k \in [\bar{k}, \bar{\bar{k}}]$. The red line is the utility level for both ESG and $NESG$ agents when $k > \bar{\bar{k}}$. Parameters are from Table 1 except that the output ratio is $\zeta = 0.25$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.



(a) Share prices at $t = 1$ (b) Share prices at S_{22}

Figure IA.27: Voice - share prices. This figure plots share prices at $t = 1$ and in state S_{22} as functions of the fraction k of ESG agents when firm B is larger than firm G. The green curve indicates the price of a green share and the brown dash-dot curve is the price of a brown share. The purple dotted lines denote the threshold level of k, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{k}}$) or all of the firm B's shares ($\hat{k}$). Parameters are from Table 1 except that the output ratio is $\zeta = 0.25$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.

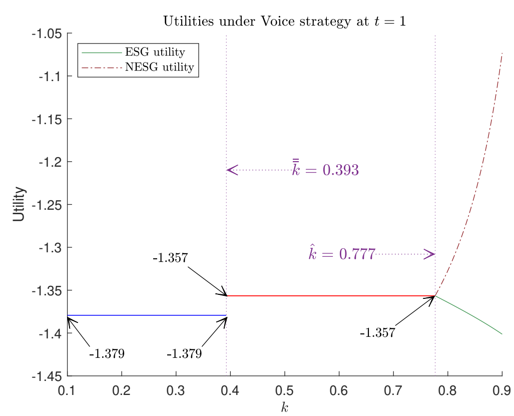


Figure IA.28: Voice - utility at $t = 1$. This figure plots utilities of individual ESG and $NESG$ agents at $t = 1$ as functions of the fraction k of ESG agents when firm B is larger than firm G. The purple dotted lines denote the threshold level of k, beyond which the ESG agents as a whole either hold the majority but not all of firm B's shares ($\bar{\bar{k}}$) or all of the firm B's shares ($\hat{k}$). The blue line is the utility level for both ESG and $NESG$ agents when $k \leq \bar{\bar{k}}$. The red line is the utility level for both ESG and $NESG$ agents when $k \in [\bar{\bar{k}}, \hat{k}]$. The green and brown lines indicate the utility levels for ESG and $NESG$ agents, respectively, when $k > \hat{k}$. Parameters are from Table 1 except that the output ratio is $\zeta = 0.25$ with the total size fixed at $D_{B3} + D_{G3} = 1.14$.

Table IA.1: Boycott - equilibrium and off-equilibrium values. This table reports the equilibrium and off-equilibrium values for three fractions k of ESG population. An off-equilibrium is defined such that the green technology is not but should have been adopted, and vice versa. Parameters are from Table 1. Off-equilibrium values are denoted by †. Share holdings that do not have a unique value are denoted by *. We use $\wedge$ to denote that the share holdings depend on holdings labeled by * in the same state.

	Symbols	$k = 0.3 < \bar{k}$	$\bar{k} < k = 0.54 < \bar{\bar{k}}$	$\bar{\bar{k}} < k = 0.65$
Price deviation	-	No	Yes	No
Adoption	-	No	No	Yes
Brown good price	$p^c_{B3}(S_{32})$	0.909	0.783	$0.494^\dagger$
Share prices	(p^s_{G1}, p^s_{B1})	$(0.570, 0.518)$	$(0.598, 0.490)$	$(0.553, 0.480)$
	$(p^s_{G2}, p^s_{B2})\,(S_{21})$	$(0.570, 0.518)$	$(0.570, 0.518)$	$(0.570, 0.518)$
	$(p^s_{G2}, p^s_{B2})\,(S_{22N})$	$(0.570, 0.518)$	$(0.611, 0.478)$	$(0.706, 0.349)^\dagger$
	$(p^s_{G2}, p^s_{B2})\,(S_{22A})$	$(0.546, 0.464)^\dagger$	$(0.546, 0.464)^\dagger$	$(0.546, 0.464)$
Holdings	$(\theta^{esg}_{G1}, \theta^{nesg}_{G1})$	$(1, 1)$	$(0.918, 1.095)$	$(1, 1)$
	$(\theta^{esg}_{B1}, \theta^{nesg}_{B1})$	$(1, 1)$	$(1.096, 0.887)$	$(1, 1)$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\,(S_{21})$	$(1, 1)^*$	$(0.918, 1.095)^*$	$(1, 1)^*$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\,(S_{21})$	$(1, 1)^\wedge$	$(1.093, 0.891)^\wedge$	$(1, 1)^\wedge$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\,(S_{22N})$	$(1, 1)^*$	$(0.918, 1.095)^*$	$(1, 1)^{\dagger *}$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\,(S_{22N})$	$(1, 1)^\wedge$	$(1.093, 0.891)^\wedge$	$(0.990, 1.019)^{\dagger\wedge}$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\,(S_{22A})$	$(1, 1)^{\dagger *}$	$(0.918, 1.095)^{\dagger *}$	$(1, 1)^*$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\,(S_{22A})$	$(1, 1)^{\dagger\wedge}$	$(1.096, 0.887)^{\dagger\wedge}$	$(1, 1)^\wedge$
Consumption	(c^{esg}_1, c^{nesg}_1)	$(1, 1)$	$(1.002, 0.998)$	$(1, 1)$
	$(c^{esg}_2, c^{nesg}_2)\,(S_{21})$	$(1, 1)$	$(1.002, 0.998)$	$(1, 1)$
	$(c^{esg}_2, c^{nesg}_2)\,(S_{22N})$	$(1, 1)$	$(1.002, 0.998)$	$(1.004, 0.993)^\dagger$
	$(c^{esg}_2, c^{nesg}_2)\,(S_{22A})$	$(1, 1)^\dagger$	$(1, 1)^\dagger$	$(1, 1)$
	$(c^{esg}_3, c^{nesg}_3)\,(S_{31})$	$(1.140, 1.140)$	$(1.142, 1.138)$	$(1.140, 1.140)$
	$(c^{esg}_3, c^{nesg}_3)\,(S_{32})$	$(1.140, 1.140)$	$(1.056, 1.239)$	$(0.877, 1.629)^\dagger$
	$(c^{esg}_3, c^{nesg}_3)\,(S_{33})$	$(1.055, 1.055)^\dagger$	$(1.055, 1.054)^\dagger$	$(1.055, 1.055)$
Utility	(U^{esg}_1, U^{nesg}_1)	$(-1.348, -1.348)$	$(-1.369, -1.326)$	$(-1.335, -1.335)$
	$(U^{esg}_2, U^{nesg}_2)\,(S_{21})$	$(-0.899, -0.899)$	$(-0.897, -0.900)$	$(-0.899, -0.899)$
	$(U^{esg}_2, U^{nesg}_2)\,(S_{22N})$	$(-0.899, -0.899)$	$(-0.929, -0.865)$	$(-1.003, -0.756)^\dagger$
	$(U^{esg}_2, U^{nesg}_2)\,(S_{22A})$	$(-0.879, -0.879)^\dagger$	$(-0.879, -0.879)^\dagger$	$(-0.879, -0.879)$
	$(U^{esg}_3, U^{nesg}_3)\,(S_{31})$	$(-0.449, -0.449)$	$(-0.449, -0.450)$	$(-0.449, -0.449)$
	$(U^{esg}_3, U^{nesg}_3)\,(S_{32})$	$(-0.449, -0.449)$	$(-0.481, -0.415)$	$(-0.555, -0.304)^\dagger$
	$(U^{esg}_3, U^{nesg}_3)\,(S_{33})$	$(-0.430, -0.430)^\dagger$	$(-0.430, -0.430)^\dagger$	$(-0.430, -0.430)$

Table IA.2: Voice - equilibrium and off-equilibrium values. This table reports the equilibrium and off-equilibrium values for three fractions k of ESG population. An off-equilibrium is defined such that the green technology is not but should have been adopted, and vice versa. Parameters are from Table 1. Off-equilibrium values are denoted by †. Share holdings that do not have a unique value are denoted by *. We use $\wedge$ to denote that the share holdings depend on holdings labeled by * in the same state.

	Symbols	$k = 0.15 < \bar{\bar{k}}$	$\bar{\bar{k}} < k = 0.35 < \hat{k}$	$\hat{k} < k = 0.65$
Price deviation	-	No	No	Yes
Adoption	-	No	Yes	Yes
Share prices	(p^s_{G1}, p^s_{B1})	$(0.570, 0.518)$	$(0.553, 0.480)$	$(0.392, 0.577)$
	$(p^s_{G2}, p^s_{B2})\ (S_{21})$	$(0.570, 0.518)$	$(0.570, 0.518)$	$(0.570, 0.518)$
	$(p^s_{G2}, p^s_{B2})\ (S_{22N})$	$(0.570, 0.518)$	$(0.570, 0.518)^{\dagger}$	$(0.570, 0.518)^{\dagger}$
	$(p^s_{G2}, p^s_{B2})\ (S_{22A})$	$(0.546, 0.464)^{\dagger}$	$(0.546, 0.464)$	$(0.546, 0.464)$
Holdings	$(\theta^{esg}_{G1}, \theta^{nesg}_{G1})$	$(0, 1.176)$	$(0, 1.538)$	$(0, 2.857)$
	$(\theta^{esg}_{B1}, \theta^{nesg}_{B1})$	$(2.100, 0.806)$	$(2.151, 0.380)$	$(1.538, 0)$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\ (S_{21})$	$(1, 1)^{*}$	$(1, 1)^{*}$	$(1, 1)^{*}$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\ (S_{21})$	$(1, 1)^{\wedge}$	$(1.026, 0.986)^{\wedge}$	$(0.719, 1.521)^{\wedge}$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\ (S_{22N})$	$(1, 1)^{*}$	$(1, 1)^{\dagger *}$	$(1, 1)^{\dagger *}$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\ (S_{22N})$	$(1, 1)^{\wedge}$	$(1.026, 0.986)^{\dagger \wedge}$	$(0.719, 1.521)^{\dagger \wedge}$
	$(\theta^{esg}_{G2}, \theta^{nesg}_{G2})\ (S_{22A})$	$(1, 1)^{\dagger *}$	$(1, 1)^{*}$	$(1, 1)^{*}$
	$(\theta^{esg}_{B2}, \theta^{nesg}_{B2})\ (S_{22A})$	$(0.963, 1.007)^{\dagger \wedge}$	$(0.988, 1.006)^{\wedge}$	$(0.688, 1.580)^{\wedge}$
Consumption	(c^{esg}_1, c^{nesg}_1)	$(1, 1)$	$(1, 1)$	$(1.081, 0.849)$
	$(c^{esg}_2, c^{nesg}_2)\ (S_{21})$	$(1, 1)$	$(1.013, 0.993)$	$(0.855, 1.270)$
	$(c^{esg}_2, c^{nesg}_2)\ (S_{22N})$	$(1, 1)$	$(1.013, 0.993)^{\dagger}$	$(0.855, 1.270)^{\dagger}$
	$(c^{esg}_2, c^{nesg}_2)\ (S_{22A})$	$(0.982, 1.003)^{\dagger}$	$(0.994, 1.003)$	$(0.849, 1.281)$
	$(c^{esg}_3, c^{nesg}_3)\ (S_{31})$	$(1.140, 1.140)$	$(1.153, 1.133)$	$(0.995, 1.410)$
	$(c^{esg}_3, c^{nesg}_3)\ (S_{32})$	$(1.140, 1.140)$	$(1.153, 1.133)^{\dagger}$	$(0.995, 1.410)^{\dagger}$
	$(c^{esg}_3, c^{nesg}_3)\ (S_{33})$	$(1.036, 1.058)^{\dagger}$	$(1.048, 1.058)$	$(0.903, 1.335)$
Utility	(U^{esg}_1, U^{nesg}_1)	$(-1.348, -1.348)$	$(-1.335, -1.335)$	$(-1.419, -1.216)$
	$(U^{esg}_2, U^{nesg}_2)\ (S_{21})$	$(-0.899, -0.899)$	$(-0.889, -0.904)$	$(-1.010, -0.724)$
	$(U^{esg}_2, U^{nesg}_2)\ (S_{22N})$	$(-0.899, -0.899)$	$(-0.889, -0.904)^{\dagger}$	$(-1.010, -0.724)^{\dagger}$
	$(U^{esg}_2, U^{nesg}_2)\ (S_{22A})$	$(-0.892, -0.877)^{\dagger}$	$(-0.884, -0.877)$	$(-0.993, -0.703)$
	$(U^{esg}_3, U^{nesg}_3)\ (S_{31})$	$(-0.449, -0.449)$	$(-0.445, -0.452)$	$(-0.505, -0.362)$
	$(U^{esg}_3, U^{nesg}_3)\ (S_{32})$	$(-0.449, -0.449)$	$(-0.445, -0.452)^{\dagger}$	$(-0.505, -0.362)^{\dagger}$
	$(U^{esg}_3, U^{nesg}_3)\ (S_{33})$	$(-0.436, -0.429)^{\dagger}$	$(-0.432, -0.429)$	$(-0.485, -0.344)$

Table IA.3: Exit - multiple equilibria. This table shows share prices and returns for certain values of k, where multiple equilibria may exist. Parameters are from Table 1. An off-equilibrium is defined such that the green technology is not but should have been adopted, and vice versa, and it is denoted by †.

	Symbols	$k = 0.570$	$k = 0.576$	$k = 0.5765$	$k = 0.577$
Type of equilibrium	-	Pure	(Pure 1, Pure 2, Mixed)	(Mixed 1, Mixed 2, Pure)	Pure
Adoption probability ψ	-	0	$(0, 1, 0.950)$	$(0.245, 0.886, 1)$	1
Green share prices	$p_{G2}(S_1)$	0.600	$(0.604, 0.553, 0.556)$	$(0.591, 0.559, 0.553)$	0.553
	$p_{G2}(S_{21})$	0.570	$(0.570, 0.570, 0.570)$	$(0.570, 0.570, 0.570)$	0.570
	$p_{G2}(S_{22N})$	0.613	$(0.618, 0.620^\dagger, 0.618)$	$(0.618, 0.618, 0.620^\dagger)$	$0.621^\dagger$
	$p_{G2}(S_{22A})$	$0.546^\dagger$	$(0.546^\dagger, 0.546, 0.546)$	$(0.546, 0.546, 0.546)$	0.546
Brown share prices	$p_{B2}(S_1)$	0.485	$(0.4803, 0.4801, 0.4801)$	$(0.4801, 0.4801, 0.4801)$	0.4801
	$p_{B2}(S_{21})$	0.518	$(0.518, 0.518, 0.518)$	$(0.518, 0.518, 0.518)$	0.518
	$p_{B2}(S_{22N})$	0.471	$(0.4641, 0.462^\dagger, 0.4638)$	$(0.4638, 0.4638, 0.462^\dagger)$	$0.461^\dagger$
	$p_{B2}(S_{22A})$	$0.464^\dagger$	$(0.4638^\dagger, 0.4638, 0.4638)$	$(0.4638, 0.4638, 0.4638)$	0.4638
Green share returns	$S_1 \to S_{21}$	-0.050	$(-0.056, 0.031, 0.026)$	$(-0.036, 0.020, 0.031)$	0.031
	$S_1 \to S_{22N}$	0.021	$(0.024, 0.121^\dagger, 0.113)$	$(0.046, 0.107, 0.122^\dagger)$	$0.123^\dagger$
	$S_1 \to S_{22A}$	$-0.091^\dagger$	$(-0.096^\dagger, -0.013, -0.018)$	$(-0.077, -0.023, -0.013)$	-0.013
	$S_{21} \to S_{31}$	0	$(0, 0, 0)$	$(0, 0, 0)$	0
	$S_{22N} \to S_{32}$	-0.070	$(-0.078, -0.080^\dagger, -0.078)$	$(-0.078, -0.078, -0.081^\dagger)$	$-0.082^\dagger$
	$S_{22A} \to S_{33}$	$0.045^\dagger$	$(0.045^\dagger, 0.045, 0.045)$	$(0.045, 0.045, 0.045)$	0.045
Brown share returns	$S_1 \to S_{21}$	0.069	$(0.079, 0.079, 0.079)$	$(0.079, 0.079, 0.079)$	0.079
	$S_1 \to S_{22N}$	-0.029	$(-0.0338, -0.037^\dagger, -0.0339)$	$(-0.0339, -0.0339, -0.038^\dagger)$	$-0.039^\dagger$
	$S_1 \to S_{22A}$	$-0.043^\dagger$	$(-0.0344^\dagger, -0.0340, -0.0339)$	$(-0.0339, -0.0339, -0.0339)$	-0.0339
	$S_{21} \to S_{31}$	0	$(0, 0, 0)$	$(0, 0, 0)$	0
	$S_{22N} \to S_{32}$	0.101	$(0.116, 0.121^\dagger, 0.117)$	$(0.117, 0.117, 0.122^\dagger)$	$0.123^\dagger$
	$S_{22A} \to S_{33}$	$0.045^\dagger$	$(0.045^\dagger, 0.045, 0.045)$	$(0.045, 0.045, 0.045)$	0.045

Table IA.4: Exit - equilibrium and off-equilibrium values. This table reports the equilibrium and off-equilibrium values for three different λ when the fraction of ESG agents is $k = 0.65$. An off-equilibrium is defined such that the green technology is not but should have been adopted, and vice versa. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1. Off-equilibrium values are denoted by †. Share holdings that do not have a unique value are denoted by *. We use $\wedge$ to denote that the share holdings depend on holdings labeled by * in the same state.

	State	Symbols	$\lambda = 0.3 < \bar{\lambda}$	$\bar{\lambda} < \lambda = 0.59 < \bar{\bar{\lambda}}$	$\bar{\bar{\lambda}} < \lambda = 0.8$
Endowments		$(\psi_1^{esg}, \psi_1^{nesg})$	$(0.550, 1.835)$	$(0.804, 1.363)$	$(0.920, 1.149)$
		$(\psi_2^{esg}, \psi_2^{nesg})$	$(0.550, 1.835)$	$(0.804, 1.363)$	$(0.920, 1.149)$
		$(\theta_{G0}^{esg}, \theta_{G0}^{nesg}, \theta_{B0}^{esg}, \theta_{B0}^{nesg})$	$(0.550, 1.835, 0.550, 1.835)$	$(0.804, 1.363, 0.804, 1.363)$	$(0.920, 1.149, 0.920, 1.149)$
Price deviation		-	No	Yes	No
Adoption		-	No	No	Yes
Share prices	S_1	(p_{G1}^s, p_{B1}^s)	$(0.570, 0.518)$	$(0.573, 0.513)$	$(0.553, 0.480)$
	S_{21}	(p_{G2}^s, p_{B2}^s) (S_{21})	$(0.570, 0.518)$	$(0.570, 0.518)$	$(0.570, 0.518)$
	S_{22N}	(p_{G2}^s, p_{B2}^s)	$(0.570, 0.518)$	$(0.575, 0.511)$	$(0.631, 0.429)^\dagger$
	S_{22A}	(p_{G2}^s, p_{B2}^s)	$(0.546, 0.464)^\dagger$	$(0.546, 0.464)^\dagger$	$(0.546, 0.464)$
Returns		$(G_{22N\to32}, B_{22N\to32})$	$(0, 0)$	$(-0.008, 0.015)$	$(-0.097, 0.208)^\dagger$
		$(G_{22A\to33}, B_{22A\to33})$	$(0.045, 0.045)^\dagger$	$(0.045, 0.045)^\dagger$	$(0.045, 0.045)$
Holdings	S_1	$(\theta_{G1}^{esg}, \theta_{G1}^{nesg})$	$(0.559, 1.820)$	$(0.773, 1.421)$	$(0.851, 1.277)$
	S_1	$(\theta_{B1}^{esg}, \theta_{B1}^{nesg})$	$(0.567, 1.803)$	$(0.850, 1.278)$	$(1.002, 0.996)$
	S_{21}	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})$	$(0.559, 1.820)^*$	$(0.773, 1.421)^*$	$(0.851, 1.277)^*$
	S_{21}	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})$	$(0.593, 1.756)^\wedge$	$(0.861, 1.258)^\wedge$	$(1.005, 0.990)^\wedge$
	S_{22N}	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})$	$(1.097, 0.819)$	$(1.538, 0)$	$(1.538, 0)^\dagger$
	S_{22N}	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})$	$(0, 2.857)$	$(0, 2.857)$	$(0, 2.857)^\dagger$
	S_{22A}	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})$	$(0.559, 1.820)^{\dagger *}$	$(0.773, 1.421)^{\dagger *}$	$(0.851, 1.277)^*$
	S_{22A}	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})$	$(0.580, 1.780)^{\dagger \wedge}$	$(0.857, 1.266)^{\dagger \wedge}$	$(1.006, 0.989)^\wedge$
Consumption	S_1	(c_1^{esg}, c_1^{nesg})	$(0.537, 1.859)$	$(0.799, 1.374)$	$(0.918, 1.153)$
	S_{21}	(c_2^{esg}, c_2^{nesg})	$(0.537, 1.859)$	$(0.799, 1.374)$	$(0.918, 1.153)$
	S_{22N}	(c_2^{esg}, c_2^{nesg})	$(0.537, 1.859)$	$(0.799, 1.374)$	$(0.916, 1.157)^\dagger$
	S_{22A}	(c_2^{esg}, c_2^{nesg})	$(0.545, 1.846)^\dagger$	$(0.801, 1.369)^\dagger$	$(0.918, 1.153)$
	S_{31}	(c_3^{esg}, c_3^{nesg})	$(0.677, 1.999)$	$(0.939, 1.514)$	$(1.058, 1.293)$
	S_{32}	(c_3^{esg}, c_3^{nesg})	$(0.677, 1.999)$	$(0.929, 1.532)$	$(0.929, 1.532)^\dagger$
	S_{33}	(c_3^{esg}, c_3^{nesg})	$(0.599, 1.900)^\dagger$	$(0.856, 1.423)^\dagger$	$(0.972, 1.207)$
Utility	S_1	(U_1^{esg}, U_1^{nesg})	$(-1.952, -0.678)$	$(-1.586, -0.996)$	$(-1.425, -1.181)$
	S_{21}	(U_2^{esg}, U_2^{nesg})	$(-1.301, -0.452)$	$(-1.056, -0.666)$	$(-0.960, -0.795)$
	S_{22N}	(U_2^{esg}, U_2^{nesg})	$(-1.301, -0.452)$	$(-1.060, -0.661)$	$(-1.013, -0.725)^\dagger$
	S_{22A}	(U_2^{esg}, U_2^{nesg})	$(-1.266, -0.447)^\dagger$	$(-1.031, -0.655)^\dagger$	$(-0.939, -0.778)$
	S_{31}	(U_3^{esg}, U_3^{nesg})	$(-0.651, -0.226)$	$(-0.528, -0.333)$	$(-0.480, -0.398)$
	S_{32}	(U_3^{esg}, U_3^{nesg})	$(-0.651, -0.226)$	$(-0.532, -0.328)$	$(-0.532, -0.328)^\dagger$
	S_{33}	(U_3^{esg}, U_3^{nesg})	$(-0.619, -0.219)^\dagger$	$(-0.504, -0.320)^\dagger$	$(-0.459, -0.381)$

Table IA.5: Boycott - equilibrium and off-equilibrium values. This table reports the equilibrium and off-equilibrium values for three different λ when the fraction of ESG agents is $k = 0.65$. An off-equilibrium is defined such that the green technology is not but should have been adopted, and vice versa. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1. Off-equilibrium values are denoted by †. Share holdings that do not have a unique value are denoted by *. We use ∧ to denote that the share holdings depend on holdings labeled by * in the same state.

	Symbols	$\lambda = 0.3 < \bar{\lambda}$	$\bar{\lambda} < \lambda = 0.59 < \bar{\bar{\lambda}}$	$\bar{\bar{\lambda}} < \lambda = 0.8$
Endowments	$(\psi_1^{esg}, \psi_1^{nesg})$	$(0.550, 1.835)$	$(0.804, 1.363)$	$(0.920, 1.149)$
	$(\psi_2^{esg}, \psi_2^{nesg})$	$(0.550, 1.835)$	$(0.804, 1.363)$	$(0.920, 1.149)$
	$(\theta_{G0}^{esg}, \theta_{G0}^{nesg}, \theta_{B0}^{esg}, \theta_{B0}^{nesg})$	$(0.550, 1.835, 0.550, 1.835)$	$(0.804, 1.363, 0.804, 1.363)$	$(0.920, 1.149, 0.920, 1.149)$
Price deviation	-	No	Yes	No
Adoption	-	No	No	Yes
Share prices	(p_{G1}^s, p_{B1}^s)	$(0.570, 0.518)$	$(0.590, 0.486)$	$(0.553, 0.480)$
	$(p_{G2}^s, p_{B2}^s)\ (S_{21})$	$(0.570, 0.518)$	$(0.570, 0.518)$	$(0.570, 0.518)$
	$(p_{G2}^s, p_{B2}^s)\ (S_{22N})$	$(0.570, 0.518)$	$(0.599, 0.473)$	$(0.655, 0.400)^\dagger$
	$(p_{G2}^s, p_{B2}^s)\ (S_{22A})$	$(0.546, 0.464)^\dagger$	$(0.546, 0.464)^\dagger$	$(0.546, 0.464)$
Holdings	$(\theta_{G1}^{esg}, \theta_{G1}^{nesg})$	$(0.558, 1.820)$	$(0.817, 1.340)$	$(0.851, 1.277)$
	$(\theta_{B1}^{esg}, \theta_{B1}^{nesg})$	$(0.567, 1.803)$	$(0.801, 1.370)$	$(1.002, 0.996)$
	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})\ (S_{21})$	$(0.558, 1.820)^*$	$(0.817, 1.340)^*$	$(0.851, 1.277)^*$
	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})\ (S_{21})$	$(0.593, 1.756)^\wedge$	$(0.812, 1.349)^\wedge$	$(1.005, 0.990)^\wedge$
	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})\ (S_{22N})$	$(0.558, 1.820)^*$	$(0.817, 1.340)^*$	$(0.851, 1.277)^\dagger$
	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})\ (S_{22N})$	$(0.593, 1.756)^\wedge$	$(0.813, 1.347)^\wedge$	$(1.025, 0.954)^\dagger$
	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})\ (S_{22A})$	$(0.558, 1.820)^{\dagger *}$	$(0.817, 1.340)^{\dagger *}$	$(0.851, 1.277)^*$
	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})\ (S_{22A})$	$(0.580, 1.780)^{\dagger \wedge}$	$(0.806, 1.360)^{\dagger \wedge}$	$(1.006, 0.989)^\wedge$
Consumption	(c_1^{esg}, c_1^{nesg})	$(0.537, 1.859)$	$(0.798, 1.374)$	$(0.918, 1.153)$
	$(c_2^{esg}, c_2^{nesg})\ (S_{21})$	$(0.537, 1.859)$	$(0.798, 1.374)$	$(0.918, 1.153)$
	$(c_2^{esg}, c_2^{nesg})\ (S_{22N})$	$(0.537, 1.859)$	$(0.798, 1.374)$	$(0.911, 1.166)^\dagger$
	$(c_2^{esg}, c_2^{nesg})\ (S_{22A})$	$(0.545, 1.846)^\dagger$	$(0.802, 1.368)^\dagger$	$(0.918, 1.153)$
	$(c_3^{esg}, c_3^{nesg})\ (S_{31})$	$(0.677, 1.999)$	$(0.938, 1.514)$	$(1.058, 1.293)$
	$(c_3^{esg}, c_3^{nesg})\ (S_{32})$	$(0.677, 1.999)$	$(0.877, 1.629)$	$(0.877, 1.629)^\dagger$
	$(c_3^{esg}, c_3^{nesg})\ (S_{33})$	$(0.599, 1.900)^\dagger$	$(0.856, 1.422)^\dagger$	$(0.972, 1.207)$
Utility	(U_1^{esg}, U_1^{nesg})	$(-1.952, -0.678)$	$(-1.602, -0.979)$	$(-1.425, -1.181)$
	$(U_2^{esg}, U_2^{nesg})\ (S_{21})$	$(-1.301, -0.452)$	$(-1.056, -0.666)$	$(-0.960, -0.795)$
	$(U_2^{esg}, U_2^{nesg})\ (S_{22N})$	$(-1.301, -0.452)$	$(-1.083, -0.637)$	$(-1.037, -0.697)^\dagger$
	$(U_2^{esg}, U_2^{nesg})\ (S_{22A})$	$(-1.266, -0.447)^\dagger$	$(-1.031, -0.655)^\dagger$	$(-0.939, -0.778)$
	$(U_3^{esg}, U_3^{nesg})\ (S_{31})$	$(-0.651, -0.226)$	$(-0.528, -0.333)$	$(-0.480, -0.398)$
	$(U_3^{esg}, U_3^{nesg})\ (S_{32})$	$(-0.651, -0.226)$	$(-0.555, -0.304)$	$(-0.555, -0.304)^\dagger$
	$(U_3^{esg}, U_3^{nesg})\ (S_{33})$	$(-0.619, -0.219)^\dagger$	$(-0.504, -0.320)^\dagger$	$(-0.459, -0.381)$

Table IA.6: Voice - equilibrium and off-equilibrium values. This table reports the equilibrium and off-equilibrium values for three different λ when the fraction of ESG agents is $k = 0.65$. An off-equilibrium is defined such that the green technology is not but should have been adopted, and vice versa. Parameters are from Table 1 except that the individual endowments vary with aggregate consumption fixed at $\psi_1 = \psi_2 = 1$ at $t = 1$ and 2 and aggregate supply of shares of each firm fixed at 1. Off-equilibrium values are denoted by †. Share holdings that do not have a unique value are denoted by *. We use $\wedge$ to denote that the share holdings depend on holdings labeled by * in the same state.

	Symbols	$\lambda = 0.1 < \bar{\bar{\lambda}}$	$\bar{\bar{\lambda}} < \lambda = 0.25 < \hat{\lambda}$	$\lambda = 0.8 < \hat{\lambda}$
Endowments	$(\psi_1^{esg}, \psi_1^{nesg})$	$(0.241, 2.410)$	$(0.488, 1.951)$	$(0.920, 1.149)$
	$(\psi_2^{esg}, \psi_2^{nesg})$	$(0.241, 2.410)$	$(0.488, 1.951)$	$(0.920, 1.149)$
	$(\theta_{G0}^{esg}, \theta_{G0}^{nesg}, \theta_{B0}^{esg}, \theta_{B0}^{nesg})$	$(0.241, 2.410, 0.241, 2.410)$	$(0.488, 1.951, 0.488, 1.951)$	$(0.920, 1.149, 0.488, 1.951)$
Price deviation	-	No	No	Yes
Adoption	-	No	Yes	Yes
Share prices	(p_{G1}^s, p_{B1}^s)	$(0.570, 0.518)$	$(0.553, 0.480)$	$(0.431, 0.549)$
	$(p_{G2}^s, p_{B2}^s)\ (S_{21})$	$(0.570, 0.518)$	$(0.570, 0.518)$	$(0.570, 0.518)$
	$(p_{G2}^s, p_{B2}^s)\ (S_{22N})$	$(0.570, 0.518)$	$(0.570, 0.518)^\dagger$	$(0.570, 0.518)^\dagger$
	$(p_{G2}^s, p_{B2}^s)\ (S_{22A})$	$(0.546, 0.464)^\dagger$	$(0.546, 0.464)$	$(0.546, 0.464)$
Holdings	$(\theta_{G1}^{esg}, \theta_{G1}^{nesg})$	$(0, 2.857)$	$(0, 2.857)$	$(0, 2.857)$
	$(\theta_{B1}^{esg}, \theta_{B1}^{nesg})$	$(0.549, 1.837)$	$(1.072, 0.866)$	$(1.538, 0)$
	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})\ (S_{21})$	$(0.241, 2.410)^*$	$(0.488, 1.951)^*$	$(0.920, 1.149)^*$
	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})\ (S_{21})$	$(0.327, 2.250)^\wedge$	$(0.555, 1.826)^\wedge$	$(0.730, 1.501)^\wedge$
	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})\ (S_{22N})$	$(0.241, 2.410)^*$	$(0.488, 1.951)^{\dagger *}$	$(0.920, 1.149)^{\dagger *}$
	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})\ (S_{22N})$	$(0.327, 2.250)^\wedge$	$(0.555, 1.826)^{\dagger \wedge}$	$(0.730, 1.501)^{\dagger \wedge}$
	$(\theta_{G2}^{esg}, \theta_{G2}^{nesg})\ (S_{22A})$	$(0.241, 2.410)^{\dagger *}$	$(0.488, 1.951)^*$	$(0.920, 1.149)^*$
	$(\theta_{B2}^{esg}, \theta_{B2}^{nesg})\ (S_{22A})$	$(0.297, 2.306)^{\dagger \wedge}$	$(0.522, 1.887)^\wedge$	$(0.698, 1.561)^\wedge$
Consumption	(c_1^{esg}, c_1^{nesg})	$(0.219, 2.451)$	$(0.477, 1.971)$	$(0.977, 1.043)$
	$(c_2^{esg}, c_2^{nesg})\ (S_{21})$	$(0.219, 2.451)$	$(0.478, 1.970)$	$(0.814, 1.345)$
	$(c_2^{esg}, c_2^{nesg})\ (S_{22N})$	$(0.219, 2.451)$	$(0.478, 1.970)^\dagger$	$(0.814, 1.345)^\dagger$
	$(c_2^{esg}, c_2^{nesg})\ (S_{22A})$	$(0.227, 2.436)^\dagger$	$(0.476, 1.972)$	$(0.808, 1.357)$
	$(c_3^{esg}, c_3^{nesg})\ (S_{31})$	$(0.359, 2.591)$	$(0.618, 2.110)$	$(0.954, 1.485)$
	$(c_3^{esg}, c_3^{nesg})\ (S_{32})$	$(0.359, 2.591)$	$(0.618, 2.110)^\dagger$	$(0.954, 1.485)^\dagger$
	$(c_3^{esg}, c_3^{nesg})\ (S_{33})$	$(0.281, 2.491)^\dagger$	$(0.531, 2.026)$	$(0.862, 1.412)$
Utility	(U_1^{esg}, U_1^{nesg})	$(-2.519, -0.422)$	$(-2.028, -0.614)$	$(-1.489, -1.101)$
	$(U_2^{esg}, U_2^{nesg})\ (S_{21})$	$(-1.679, -0.281)$	$(-1.365, -0.414)$	$(-1.043, -0.682)$
	$(U_2^{esg}, U_2^{nesg})\ (S_{22N})$	$(-1.679, -0.281)$	$(-1.365, -0.414)^\dagger$	$(-1.043, -0.682)^\dagger$
	$(U_2^{esg}, U_2^{nesg})\ (S_{22A})$	$(-1.633, -0.279)^\dagger$	$(-1.337, -0.404)$	$(-1.026, -0.661)$
	$(U_3^{esg}, U_3^{nesg})\ (S_{31})$	$(-0.840, -0.141)$	$(-0.682, -0.207)$	$(-0.521, -0.341)$
	$(U_3^{esg}, U_3^{nesg})\ (S_{32})$	$(-0.840, -0.141)$	$(-0.682, -0.207)^\dagger$	$(-0.521, -0.341)^\dagger$
	$(U_3^{esg}, U_3^{nesg})\ (S_{33})$	$(-0.799, -0.136)^\dagger$	$(-0.654, -0.198)$	$(-0.502, -0.323)$