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Seminararbeit

im Bachelorstudiengang Wirtschaftswissenschaften

über das Thema

Lobbyism and Climate Regulation Measures – Funding the Enemy of my Enemy

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Abstract

This seminar paper answers the question, why companies support environmental regulations, although it increases their own costs. A microeconomic model (Kennard, 2020) is introduced, in which companies are having heterogenous adjustment costs towards climate regulations. Companies support environmental regulations precisely when they do have a competitive advantage in terms of the model‘s *green capital*.

Zusammenfassung

Diese Seminararbeit beantwortet die Frage, wieso Unternehmen umweltpolitische Maßnahmen unterstützen, obwohl diese auch ihre eigenen Kosten erhöhen. Das vorliegende Modell (Kennard, 2020) findet eine mikroökonomische Erklärung hierfür darin, dass die Unternehmen heterogene Anpassungskosten hinsichtlich von Regulierungen besitzen. Unternehmen unterstützen im Modell genau dann umweltpolitische Maßnahmen, wenn sie einen Wettbewerbsvorteil im *grünen Kapital* genießen.

Contents

1 Introduction

From a naïve standpoint of a simple cost-benefit-analysis, companies from the manufacturing sector ought to fear climate regulations due to the increase in manufacturing cost they imply. Factoring in foreign industries makes matters worse, as sovereignity is in the so-called Westphalian system still to be considered to be within nation states (Klabbers, 2020, pp. 171–172) acting as the sole binding legislators in most cases[1], thus the scope of the companies suffering from the additional cost will be within a nation (or the respective economic area). In conclusion, increasing costs due to climate regulation imply a decreasing competitiveness of domestic producers leading to an implied aversion of domestic companies for climate regulations — at least for the regulations targeting *them*.

However, companies react differently to an increase in climate change regulation. Think of two companies A and B both competing in the same manufacturing sector M. Company A has successfully completed a program to replace most of its machinery with variants that produce more efficiently in terms of CO_2 output per unit produced. A has also strategically hired its employee stock to be aware of environmental issues and thus its whole processes are being optimized—as well as adapted—towards the goal of a more environmental friendly production. Meanwhile company B uses the industry‘s standard worth of equipment and is not only oblivious to any environmental goal setting, but— as A and B also compete on the same labor factor market— will have a implicit negative selection bias towards hiring employees more apt to deal with environmental issues. Now if a climate regulation law is passed that impacts M, in many cases this would be via increased energy costs, by intuition one would assume that not only A will suffer a relatively smaller impact on its cost side than B due to the existing state (machinery, organizational processes etc.), but also will be adapting better for the periods to come; with higher regulations this effectively increases A‘s relative market share as opposed to B as a *indirect* effect of climate regulation adjustments. The indirect effect could even be so strong to cause excess profits larger than the incurred costs of the regulations.

In a sense A is capitalized better towards environmental goals, and this is what the term *green*

[1]The EU – as an intergovernmental organization (IGO) – is an important exception. One could argue for the following research analysis, to view the EU as the legislator instead of the respective nations and the Union‘s economic area as the boundary for the manufacturing sector in question. In fact, by Art. 288 TFEU the EU may issue directives that is binding for the national states‘legislations, leaving only form and method open for the national legislator‘s decision (Schütze, 2015, pp. 247–248).

capital is defined as. A company with a higher green capital will suffer lower adjustment costs than a company with a lower green capital.

Thus in a larger setting of a domestic market in the manufacturing sector M, the green capitalization of the companies differ and thus, there is an incentive (or at least a smaller disincentive) for companies with relatively high green capitalization to opt for climate regulations as this would relatively punish competitors with a low green capitalization harder than it does the aforementioned ones. To be incentivized to *be for* climate regulations boils down to *lobby* policy makers to increase regulations.[2]

This gives rise to the paper‘s major question (cf. Kennard, 2020, p. 188) to be answered,

> “Why do some firms support costly [climate change] legislation while others continue to oppose?”

As much as this question is to be tackled as a question in the field of Economics—the object of study being the behaviour of firms[3]—, more precisely by methods of game theory. It is, however, to be noted that not only does the question explicitly refers to “legislation”, but also questions regarding climate change are inherently political as well (Meckling & Karplus, 2023). While the “legislative” part gets implicitly abstracted away by framing the question on the level of a nation state (or the EU policy space), the “political” aspect is reduced to encompass the act of *lobbyism* in a single jurisdiction.

But where would advantages in regards to the adjustment costs actually come from (cf. Kennard, 2020, pp. 188–189)? First of all the the ex-ante capital stock may be invested into machinery more efficient, especially when it is newer. This can be seen as green capital in a narrow sense. This factor also relates to the entry time into the market. Note that “first mover” advantages are not necessarily given, as can be seen as Germany‘s nation wide early adaption of photovoltaics (Quitzow, 2015, p. 126) A second type of advantages stems from existing contracts (and supply chains) in place, i.e. having secured a high percentage of the consumed energy contractually secured to be generated by renewable sources. Third, the costs may vary with the locations of the production facilities.

In the remainder of this work, a model is introduced to answer the question of when a company lobbies for climate regulations given its relative advantage in terms of green capital.

[2]Because only *lawful* with respect to national law are considered, although lobbying may be practically a somewhat shadowy way of influence. Activism is considered a (possibly) unlawful activity, although this does not imply that these activities were without any objective morals (Paulot & Irvine, 2023, p. 7). Lobbying is sometimes defined as a mere transfer of information (Grossman & Helpman, 2001, p. 104), but here money in form of donations transfer (even though the donation schemes will be known to the policy maker— a transfer of information).

[3]Firms are understood to be companies. A firm is the naming of a company as presented to the outside, likely stemming from the German word *Firmierung*. In the German commercial law (*Handelsrecht*) there are specific rulings regarding the firmation of a company (§§ 17 ff HGB). It should be self-explanatory that companies (and not their names) are the primary objects of study in Economics and from here onwards.

2 Background: Literature and Data

2.1 Literature

In (Meng & Rode, 2019, p. 472) a statistical analysis shows that the firms lobbying *against* the Waxman-Markey bill—an attempt to implement the Kyoto Protocol in the U.S.A.—were more successful and decreased the likelihood by 13 percent as well as incurring an expected social cost of 60 billion USD.

Delmas et al., 2016 find a U-shaped supporting curve, i.e. companies on the extreme polluting or green side will spend most for lobbying.

For the situation in a non-democratic, quasi-authoritarian state: (Zhang et al., 2016, p. 1307) describe how "charitable donations" work for Chinese firms, which is at least partly related to lobbying in the sense that it may be considered a corporate political activity (CPA). (Mori, 2021) analyses heterogenous firm factors of Chinese power producers in the face of environmental regulation.

The effect of climate regulations on Norway's fish farming industry is presented in (Vormedal & Skjærseth, 2020), where large, multinational companies are found to support climate regulations as opposed to small companies. This is due to the large companies to be able to more readily adapt to regulation, a form of the effect of scale economic in compliance (ibid., p. 532).

In (Cai & Li, 2020) the situation is analysed between a large clean firm vs a small dirty firm and how they influence a policy maker with regards to clime regulations. This is—on a theoretical level as to the lack of empirical backing— very similar as the model discussed here, with the difference almost just being algebraic in nature (the clean firm has only a factor $\delta \in (0, 1)$ of the environmental tax τ to pay, where the dirty firm has to pay the full tax). However, it also models the social welfare being taken into account by the policy maker (ibid., p. 545). As a result, the model is harder to generalize to the more general case of N firms.

For more literature reviews see (ibid., pp. 542–544) and (Kennard, 2020, pp. 190–191).

2.2 Data

From 2000 to 2016 more than two billion USD (adjusted to 2016‘s price levels) has been spent on climate lobbying, the maximum spending being hit in 2009 (Brulle, 2018, p. 295).

As an empirical backing the situation in the U.S. is presented as is summarized in (Kennard, 2020, pp. 188–197), see Figure 2.1.

In the EU the European Union Emissions Trading System (EU ETS – 2003/87/EC) as the first large scale “cap-and-trade” emission system was introduced in 2005, which was motivated by the Kyoto Protocol (Ellerman & Buchner, 2007, p. 66–67). Although during the design of the EU ETS experiences from the U.S. sulfur dioxide (SO_2) cap program could be used (ibid., p. 68), the U.S. does not have a similar cap-and-trade system for greenhouse gases (GHG) in place. This was, however, tried in 2009 during the Obama presidency with the Waxman-Markey-Bill which passed the U.S. house (H.R. 2454), but failed to pass the U.S. senate.

While some sectors, such as coal producers which spent 34 million USD for lobbying *against* (Downie, 2017, p. 587), uniformly opposed the Waxman-Markey bill (ibid., p. 589), in other sectors there can be observed division (see Figure 2.1 (a)).

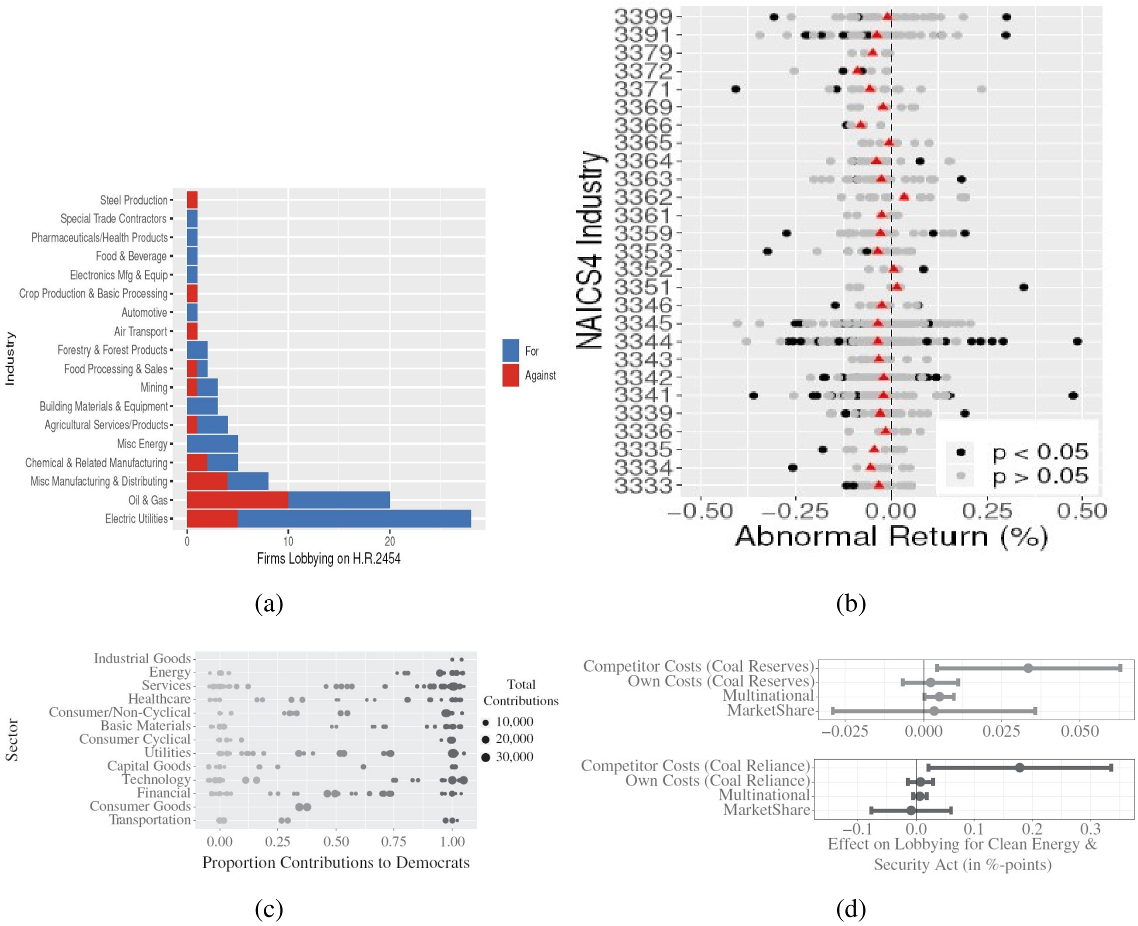

Figure 2.1: (a) Distribution of firms by industry lobbying for (defined as spending money to the democratic party *and* supporting the bill in public) and against the American Clean Energy and Security Act. (Source: Kennard, 2020, Appendix p.12) (b) The result of an classic (i.e. not Bayesian) event study (Kothari & Warner, 2006) on the passing of the Waxman-Markey-Bill through the U.S. house. The red triangles are sector averages which are given by NAICS4 Industry codes (mostly codes in manufacturing). Note that since the law didn't pass the senate (nor president) the analysis is counterfactual (Source: cf. Kennard, 2020, p. 197, appendix pp. 20–23). (c) Contributions by Fortune 500 executives to members of House Energy and Commerce Committee during 111th Congress. The more right the data points are placed, the more pro cap-and-trade (i.e. Democrats as these overwhelmingly supported the bill (Downie, 2017, p. 587)) the contribution is. Contribution data from Bonica 2017. (Source: Kennard, 2020, p. 193). (d) The figure shows 95% confidence intervals on the relation between the sectors' average firms' energy adjustment costs and input variables such as the coal reliance of the competition, a factor indicating a poor adjustment cost for climate related regulations (Source: Kennard, 2020, p 207).

3 The model

3.1 The regulation lobby game and its equilibrium

The *regulation lobby game* is a two-phase model, in where in the first phase the policy related variables are selected and in the second phase a (Cournot[1]) single good competition is held among two competing companies.

The player set of the game consists out of two companies and a policy maker. Futhermore, a maximum possible regulation $R > 0$, and an exogenous ideal regulation for the policy maker $\overline{R} \in [0, R]$ is given. In the numerical examples, setting $R = 2\overline{R}$ yielded decent results. The ideal policy $\overline{R}$ can be imagined to encode the political necessities: “ideology”, the electorate, and other influences (most importantly of special interest groups such as NGOs).

In the first phase (*initial phase*), the companies select their individual *contribution schemes*[2]

$$s_i : [0, R] \to \mathbb{R}_{\geq 0} \qquad (i = 1, 2).$$

Which leads to the policy maker optimizing his regulation, given the objective,

$$g(r \mid s_1, s_2, \overline{R}) = \lambda\,\omega(r) + (1 - \lambda)(s_1(r) + s_2(r)) \qquad (r \in [0, R]). \tag{3.1}$$

with the punishment term $\omega(r) = -(r - \overline{R})^2$ taken as the squared distance to the policy maker‘s ideal regulation and $\lambda \in [0, 1]$ as a weight factor. A – highly unrealistic – policy maker with $\lambda = 1$ would show disinterest towards donations, and not allow for any change of his regulation plan to reach $\overline{R}$, while in the $\lambda = 0$ case the policy maker would be a political grifter vying for donations, while ignoring the electorate.

In the second phase (*competition phase*) the companies compete on a Cournot single homogenous good market, with inverse demand function $P = [a - Q]_{a \geq Q}$[3] and asymmetric

[1] Can also be done with a Bertrand price competition.

[2] Functions are understood to be piecewise (two times) continuously differentiable if not said otherwise.

[3] The notation signifies that the function is zero if the condition $a \geq Q$ is not fulfilled. In the following, this is often omitted, if deemed not important. The notation $[a \geq Q]$ is more common, which equates to 1 if the predicate is fulfilled and 0 otherwise.

linear costs,

$$C_i(Q_i) = \frac{r}{\rho_i} Q_i, \tag{3.2}$$

where ρ_i is a firm-specific constant marginal cost factor, modeling the *green capital*, as well as the policy regulation — the one chosen just before in the initial phase — r. In our two company setting, we assume $\rho_1 > \rho_2$, i.e. the first firm has better green capital and is more cost-efficient with regards to climate regulation.

The marginal costs are thus r/ρ_i and for an adjustment of the policy r the difference on the marginals are $-(1/\rho_1 + 1/\rho_2) < -2/\rho_1$.

The game is analysed backward starting with the second phase assuming a policy r has been set.

With $Q = Q_1 + Q_2$ ($Q_i \geq 0$), the firms‘ profit functions are given by,

$$\pi_i(Q) = P(Q)Q_i - C_i(Q_i) = \left(a - Q_1 - Q_2 - \frac{r}{\rho_i}\right) Q_i. \tag{3.3}$$

a, the market‘s maximum price, is chosen reasonably large to accomodate for even the harshest regulation. We are now to derive an analytic lower bound to keep both firms in the market.

Proposition 1. *If,*

$$a > R\left(\frac{2}{\rho_2} - \frac{1}{\rho_1}\right) \tag{3.4}$$

then the companies are producing something in the equilibrium state(s), i.e. $Q_1^*, Q_2^* > 0$.

Proof. The first order conditions of the firms profits are given by,

$$\frac{\partial \pi_i(Q_1, Q_2)}{\partial Q_i} = a - 2Q_i - Q_j - \frac{r}{\rho_i} \stackrel{!}{=} 0 \qquad (i \neq j),$$

implying the firms´ reaction functions,

$$R^i(Q_j) = \frac{a - Q_j - r/\rho_i}{2}. \tag{3.5}$$

Computing the Nash-Equilibria yield,

$$Q_i^* = \frac{a + r/\rho_j - 2r/\rho_i}{3}. \tag{3.6}$$

Noting $Q_1^* > Q_2^*$ and inserting R in the inequality $Q_2^* > 0$ finishes the proof. □

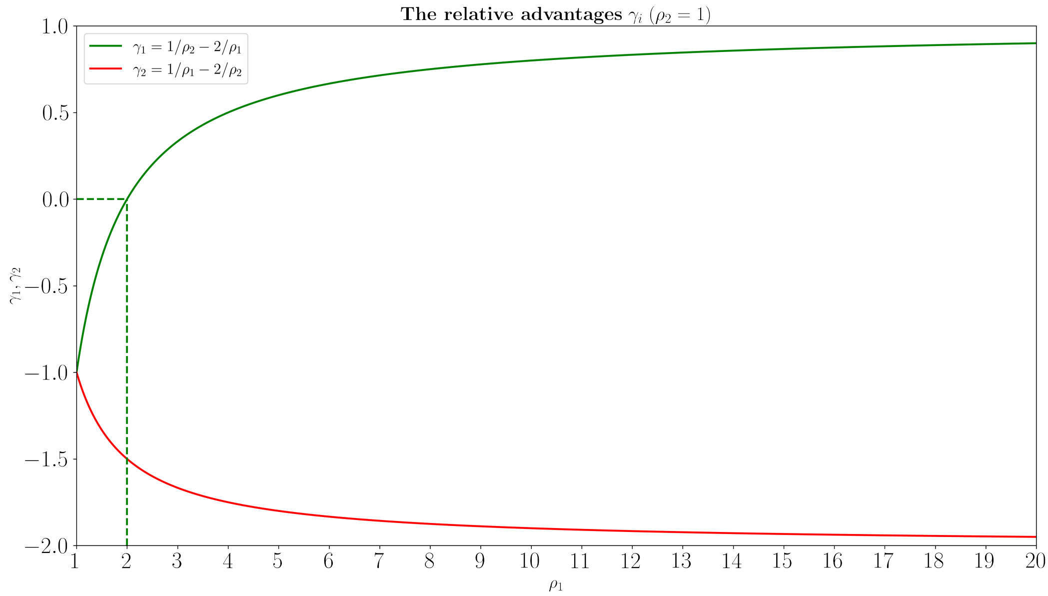

Figure 3.1: $\rho_2 = 1$, $1 \leq \rho_1 \leq 20$ to obtain the displayed factors γ_1 and γ_2. Once ρ_1 passes $2\rho_2 = 2$, γ_1 is positive.

The equation for the reaction functions 3.5 follow from (Gibbons, 1992, pp. 14–17) by setting $c_i = r/\rho_i$ (making the costs asymmetric in the analysis of the Cournot doupoly).

Note that $Q_1^* > Q_2^*$, i.e. the greener company produces more. The condition 3.4 excludes the situation in which the green company is bullying out the other one completely from the market, as the market is too big for the regulation to hit "too hard". This would also be realistic as the upper limit for the regulation R is assumed to be exogenous and taken to model what the legislator realistically would politically be able to propose, while the ideal policy (for the policy maker) $\overline{R}$ is what the particular electorate of the policy maker "wants".

By setting the quantity $\gamma_1 := 1/\rho_2 - 2/\rho_1$ (and γ_2, which is always smaller than γ_1, accordingly) as the *(weighted) relative advantage* the equilibria in equation 3.6 can be rewritten as $Q_i^* = \frac{1}{3}(a + r\gamma_i)$. Analysing the change of policy r it can thus be observed that $\partial Q_i^*/\partial r = \frac{1}{3}\gamma_i > 0$. Then $\partial Q_1^*/\partial r > 0$ if and only if $\rho_1 > 2\rho_2$. In words: the greener company, if it has at least twice the green capital than the other company, will produce *more* goods if regulation is increased. When γ_1 is precisely 0, the output remains unchanged. In the negative case, both companies will reduce their output given increasing climate regulations.

In the case of $\gamma_1 \geq 0$, the first company would be called *green*.

In numerical settings ρ_2 can be set to 1 (and $\overline{R}, R$ and ρ_1 can be rescaled accordingly) and ρ_1 varied starting from the value 1 and going larger. Figure 3.1 showcases the value of γ_1 and γ_2 with a varying green capital of ρ_1 from 1 to 20. This simplification could also be done for analytic computations without loss of generality, but this would make the resulting formulas less symmetric and harder to generalize.

Note that Equation 3.4 becomes $a > -R\gamma_2$ in which the right-hand side is positive due to

$\gamma_2 < 0$. *This is to be assumed to be the case in the rest of this paper.*

This raises the question on what the relation between γ_1 and the green company‘s profit is:

$$\begin{aligned}\pi_1^* &= \pi_1(Q_1^*, Q_2^*)\\ &= (a - Q_1^* - Q_2^*)Q_1^* - C^1(Q_1^*)\\ &= \left(a - \frac{1}{3}(a + r\gamma_1) - \frac{1}{3}(a + r\gamma_2)\right) Q_1^* - \frac{r}{\rho_1} Q_1^*\\ &= \frac{1}{3} Q_1^* \left(a - r \underbrace{(1/\rho_2 - 2/\rho_1 + 1/\rho_1 - 2/\rho_2 + 3/\rho_1)}_{=2/\rho_1 - 1/\rho_2 = -\gamma_1} \right)\end{aligned}$$

thus, also by analogy for the second company,[4]

$$\pi_i^* = [(Q_i^*)^2]_{Q_i^* \geq 0} = \frac{1}{9}(a + r\gamma_i)^2 =: \pi_i^*(r). \tag{3.7}$$

Implying that given $\gamma_i > 0$, the profits will increase with increasing regulation. However, for the second company, because of $\gamma_2 = 1/\rho_1 - 2/\rho_2 < -1/\rho_2 < 0$, the dirty company will always be hurt by additional regulation, both in profit and market share.

This is because the marginal equilibrium profit $\partial \pi_i^*(r)/\partial r = \frac{2\gamma_i}{9}(a + r\gamma_i) = \frac{2\gamma_i}{3} Q_i^*(r)$ will be negative precisely when γ_i is negative.

Making use of the results so far, in Figure 3.2 the changes in the market share of the green company is plotted against the regulation r and its green capital ρ_1. It can be seen that the larger ρ_1, the higher γ_1 is, the reaction to increases in regulation becomes more drastic.

Having analysed the competition phase, we resume the analysis with the initial phase, namely at the policy maker‘s behaviour by fixing two contribution schemes s_1, s_2 and solving the objective problem (see equation 3.1),

$$r^* = \arg\max_r \left\{ \lambda \omega(r) + (1 - \lambda)(s_1(r) + s_2(r)) \right\}. \tag{3.8}$$

Deriving the first-order condition,

$$0 \stackrel{!}{=} \left. \frac{\partial g(r \mid s_1, s_2, \overline{R})}{\partial r} \right|_{r=r^*} = -2\lambda(r^* - \overline{R}) + (1 - \lambda) \left(\left. \frac{\partial s_1(r)}{\partial r} \right|_{r=r^*} + \left. \frac{\partial s_2(r)}{\partial r} \right|_{r=r^*} \right) \tag{3.9}$$

[4] Note that we assume $Q_i^* > 0$.

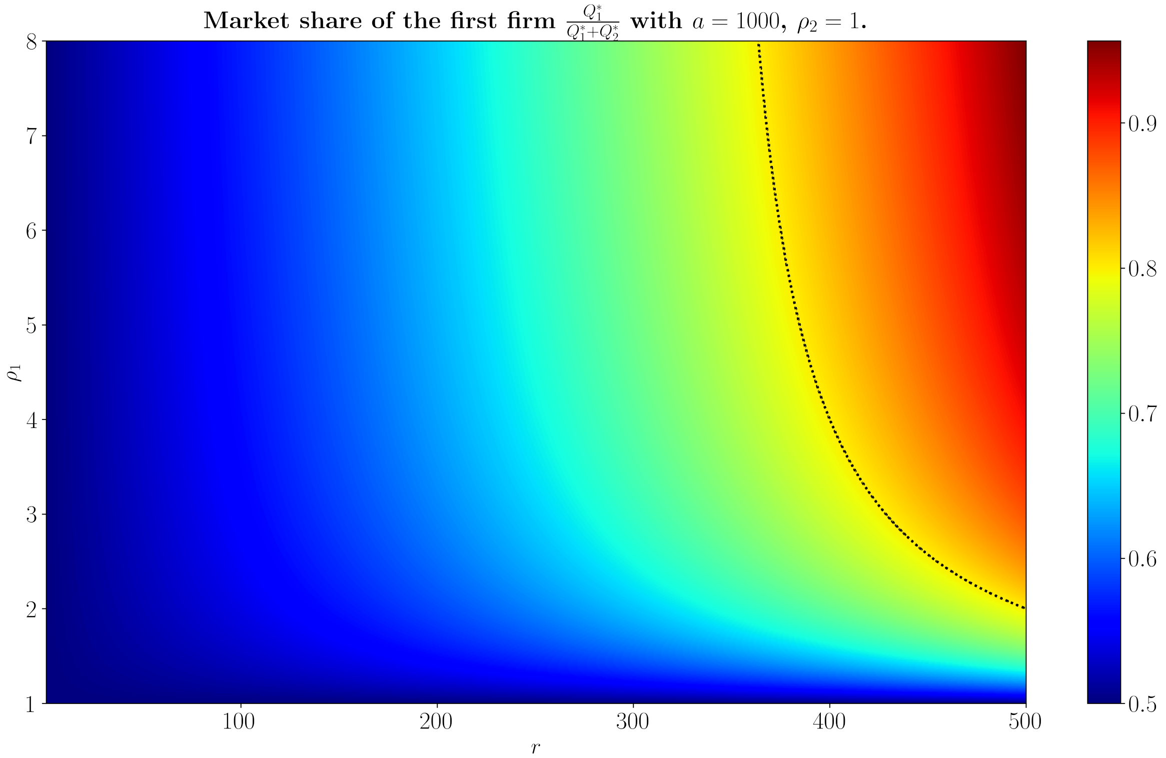

Figure 3.2: With $\rho_2 = 1$ and $a = 1000$, we vary both the regulation r from 0 to $500 = \overline{R}$ and the green capital of the "greener" firm ρ_1 from 1 (no advantage) to 8. The market share of the greener firm is calculated, and its value plotted in color. The black dashed line is the level curve for a market share of 80%.

immediately gives an analytic equation for the equilibrium policy r^*,

$$r^* = \overline{R} + \frac{(1-\lambda)}{2\lambda}\left(\left.\frac{\partial s_1(r)}{\partial r}\right|_{r=r^*} + \left.\frac{\partial s_2(r)}{\partial r}\right|_{r=r^*}\right) \tag{3.10}$$

This value is well-defined for the non-edge case $\lambda \neq 0$.

The ideal policy r^* thus is not given by the *absolute* contributions of the firms, but by the marginal contributions, i.e. the policy maker will increase regulations only if the companies are willing to contribute more to offset the cost of deviating more from the ideal policy $\overline{R}$.

In order for r^* as defined in equation 3.10 to be a (local) maximum, it must hold that:

$$\left.\frac{\partial^2 s_1(r)}{\partial^2 r}\right|_{r=r^*} + \left.\frac{\partial^2 s_2(r)}{\partial^2 r}\right|_{r=r^*} < \frac{2\lambda}{1-\lambda} \tag{3.11}$$

as if that condition were to hold for all $r \in (0, R)$, then $g(r \mid s_1, s_2, \overline{R})$ would be concave and r^* a global maximum in conclusion.

The fraction $\beta := \lambda/(1-\lambda) \in (0, \infty)$ quantifies the relative focus of the policymaker on his own policy goal, rather than to obtain contributions from the firms.

Intuitively, a firm‘s absolute contribution $s_i(r)$ should be relatively low compared to its profit

π_i. However, this does not have to be the case for the marginal rates with respect to the policy factor r. Given a (candidate) equilibrium of $\widetilde{r}^*$, the firm would wriggle its contribution to increase profits by reducing costs or – if it is green – by trying to get the policy maker to increase regulation [5], thus the relation

$$\left.\frac{\partial s_i(r)}{\partial r}\right|_{r=\widetilde{r}^*} \stackrel{?}{=} \left.\frac{\partial \pi_i(r)}{\partial r}\right|_{r=\widetilde{r}^*} \tag{3.12}$$

should give insight of firms‘ behavior with respect to their contributions. In order to get equality in equation 3.12, truthful (subgame perfect) Nash equilibria are defined (Bernheim & Whinston, 1986, p. 12). The initial phase is modeled as a *first-price menu auction*, with the firms as bidders and the policy maker as an auctioneer.

Definition 1 (Truthful Nash equilibria)**.** *A firm‘s contribution schedule $s_i : R \to \mathbb{R}$ is defined to be* truthful relative to the equilibrium policy r^**, iff.*

$$\forall r' \in [0,R] : s_i(r') - s_i(r^*) = \pi_i(r') - \pi_i(r^*) \qquad \left(if \pi_i(r') \geq \pi_i(r^*)\right),$$

or, when $\pi_i(r')$ is smaller than the equilibrium‘s profit π_i^*, then the contribution s_i at r' is zero.

A Nash equilibrium is truthful*, if all firms' contribution schemes are truthful (relative to the equilibrium‘s policy).*

Thus for $\pi_i(r') - \pi_i(r^*) > 0$, while the firm i would increase its profits by changing to r', but—if the contribution schedule s_i is truthful relative to r^*— contribute the total excess profit towards the policy maker in form of an increased contribution, i.e. the utility gain is transferred from the firms to the central policy maker.

This allows to pin down the contribution scheme on the functional level (and thus on the first- and second-derivatives):

$$s_i(r) = \begin{cases} \pi_i(r) - \underbrace{\left(\pi_i(r^*) - s_i(r^*)\right)}_{=:\delta_i(r^*)=\delta_i}, & \pi_i(r) \geq \pi_i(r^*), \\ 0, & \text{otherwise.} \end{cases} \tag{3.13}$$

Where δ_i denotes the excess of equilibrium profit after substracting the equilibrium contribution, i.e. the company‘s welfare. Note that in the nonzero case, $s_i(r)$ will be ≥ 0 (as required for contributions), because of $\delta_i \leq \pi_i(r^*) \leq \pi_i(r)$.

[5] Note that the elasticity of the policy maker‘s policy to a change of a single firm‘s contribution has not been analysed so far and is assumed to be rather low.

The truthful Nash equilibria essentially lead to the firms transfer all additional profits over an equilibrium/ideal policy r^* to the policy maker. The equation 3.12 becomes an equality, and thus the derivate of the contribution schemes at equilibria becomes handable. Note that we assume to have an ideal policy r^* already, and are now to calculate the second derivate and derive conditions for it to be an maximum solution as this would be circular. To fix this, one can just insert a general $\widetilde{r}^*$ instead of r^* in the following computation. For this value of policy, the market phase can be solved and thus the equation for the ideal profit (3.7), can be used. Thus for the first derivative,

$$\left.\frac{\partial s_i(r)}{\partial r}\right|_{r=\widetilde{r}^*} = \left.\frac{\partial \pi_i(r)}{\partial r}\right|_{r=\widetilde{r}^*} = \frac{2\gamma_i}{9}(a+\widetilde{r}^*\gamma_i), \tag{3.14}$$

and for the second one,

$$\left.\frac{\partial^2 s_i(r)}{\partial^2 r}\right|_{r=\widetilde{r}^*} = \frac{\partial}{\partial r}\left.\left[\frac{\partial \pi_i(r)}{\partial r}\right]\right|_{r=\widetilde{r}^*} = \frac{2\gamma_i^2}{9}. \tag{3.15}$$

Proposition 2. *When the inequality,*

$$\lambda > \frac{\gamma_1^2+\gamma_2^2}{9+\gamma_1^2+\gamma_2^2} =: \lambda_{min}, \tag{3.16}$$

holds, there exists a unique (truthful) Nash equilibrium for the regulation lobby game.

Proof. Plugging equation 3.15 into 3.11, we get

$$\frac{2}{9}(\gamma_1^2+\gamma_2^2) < \frac{2\lambda}{1-\lambda} = 2\beta. \tag{3.17}$$

Dividing by 2 and applying the function $x \mapsto x/(x+1)$ proves the theorem by noting that we are solving the regulation lobby game by backward induction (Gibbons, 1992, pp. 57–61). □

Remember that λ is the weighting for $\omega(r)$ the squared distance to the policy maker‘s ideal policy $\overline{R}$. It can be seen in Figure 3.3 that the lower boundary tends to be rather high, limiting the choices of λ.

Another use of assuming truthful Nash equilibria is to use the identity for the first derivative in equation 3.14 in equation 3.10, giving an alternative description of the ideal policy r^*:

Proposition 3.

$$r^* = \min\left\{\left[\frac{\overline{R}+\frac{1}{9}a\beta^{-1}(\gamma_1+\gamma_2))}{1-\frac{1}{9}\beta^{-1}(\gamma_1^2+\gamma_2^2)}\right]_{\geq 0}, R\right\} \tag{3.18}$$

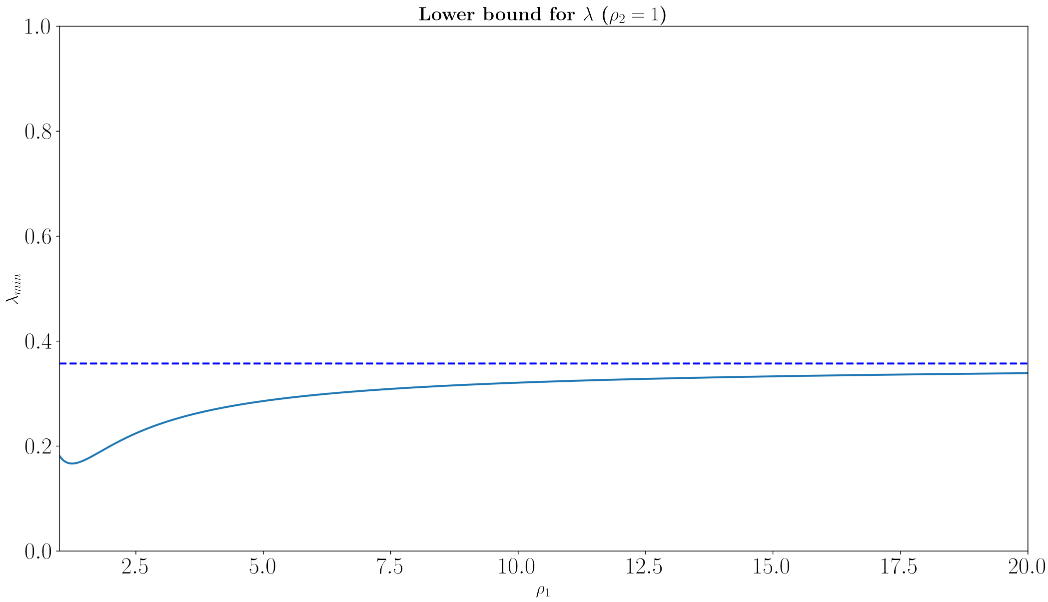

Figure 3.3: The lower bound $\lambda_{\min}$ plotted for $\rho_2 = 1 \leq \rho_1 \leq 20$. Note that the formula for the lower bound $\frac{\gamma_1^2+\gamma_2^2}{9+\gamma_1^2+\gamma_2^2}$ is equal to $\frac{5+\mathcal{O}(1/\rho_2)}{14+\mathcal{O}(1/\rho_2)} \to \frac{5}{14}$ $(\rho_2 \to \infty)$ marked as a blue dashed line in the graphic.

Proof. We obtain from the aforementioned insertion the equation

$$\begin{aligned} r^* &= \overline{R} + \frac{1}{2\beta}\left(\frac{2\gamma_1}{9}(a+r^*\gamma_1) + \frac{2\gamma_2}{9}(a+r^*\gamma_2)\right) \\ &= \overline{R} + \frac{1}{2\beta}\left(\frac{2a(\gamma_1+\gamma_2)+2r^*\left(\gamma_1^2+\gamma_2^2\right)}{9}\right) \\ &= \overline{R} + \frac{1}{9}a\beta^{-1}(\gamma_1+\gamma_2) + \frac{1}{9}\beta^{-1}(\gamma_1^2+\gamma_2^2)r^* \end{aligned}$$

Substracting the last term on the right-hand side and dividing by the resulting factor $(1 - \frac{1}{9}\beta^{-1}\left(\gamma_1^2+\gamma_2^2\right)$ of r^* on the left-hand side concludes the proof. □

Note that $\gamma_1 + \gamma_2 = -(1/\rho_1 + 1/\rho_2) < 0$ – the average cost of increasing regulation – and $\gamma_1^2 + \gamma_2^2 = 5/\rho_1^2 + 5/\rho_2^2 - 4/(\rho_1\rho_2)$. As we set $\rho_2 = 1$ in the numerical examples, the last equation inserted into the denominator of equation 3.18 to see when the denominator becomes negative, gives the condition $\rho_1 < \frac{1}{9\beta-5}$. Cases in which the fraction in equation 3.18 would be negative if they were not set to zero are called *degenerate*. In these examples the companies would—theoretically—pay the policy maker for subsidies for producing environmental damages.

This result in turn allows us to describe the contribution at the ideal policy $s_i(r^*)$ further. We define the optimal policy for player j only, by setting the other players $s_i = r \mapsto 0$ as the zero contribution,

$$r_j^* = \underset{r\in[0,R]}{\arg\max} \left(-\lambda(\overline{R}-r)^2 + (1-\lambda)s_j(r)\right). \tag{3.19}$$

A derivation similar, simply setting the values for firm i to zero, to the proof of Proposition 3 yields,

$$r_j^* = \left[\frac{\overline{R} + \frac{1}{9}a\beta^{-1}\gamma_j}{1-\frac{1}{9}\beta^{-1}\gamma_j^2}\right]_{\geq 0} \tag{3.20}$$

Note that the value of r_j^* is below $\overline{R}$ iff. $\gamma_j < 0$, i.e. the ideal policy for the firm j is below the ideal policy of the policy maker.

Revisiting equation 3.13 for the firm´s contribution scheme, it shows that $s_i(r)$ depends on the difference of the firm's profit at r and at the equilibria regulation r^*, as well as $s_i(r^*)$. Computing this quantity is the last basic theorem needed to describe the regulation lobby game:

Proposition 4. *For $i, j \in [2], i \neq j$, firm i's equilibrium contribution is,*

$$s_i(r^*) = \beta \underbrace{\left((\overline{R}-r^*)^2 - (\overline{R}-r_j^*)^2\right)}_{\omega(r_j^*)-\omega(r^*)} + (\pi_j(r_j^*) - \pi_j(r^*)). \tag{3.21}$$

Proof. Under our assumptions we do have the "global" equilibrium policy r^* as well as the equilibrium policies r_1^* and r_2^* that are the solutions to the game if the other company choose a zero contribution (i.e. is not taking part in the lobbying part of the game).

Fix $i \neq j$; $g(r^*) \geq g(r_j^*)$ does strictly not already follow from the equilibrium property as $s_i(r^*) > 0 = s_i(r_j^*)$, i.e. both players may change their contributions and strategies *simultaneously*. However, as both contributions are non-negative, if firm i is also contributing, then the policy maker must be off at least as good, because the contribution of firm i could be ignored starting from r^* to r_i^*, if it were advantageous for the policy maker. Furthermore, it cannot be that $g(r^*) > g(r_j^*)$, because then firm i could reduce its equilibrium spending (compared to the situation of r_j^* where it would spend nothing) but the policy maker would still be "stuck" with r^*.

Writing out $g(r^*) = g(r_j^*)$ and dividing by $(1-\lambda)$ (to get $\beta = \lambda/(1-\lambda)$) gives the equation,

$$\beta\omega(r^*) + s_i(r^*) + s_j(r^*) = \beta\omega(r_j^*) + s_j(r_j^*). \tag{3.22}$$

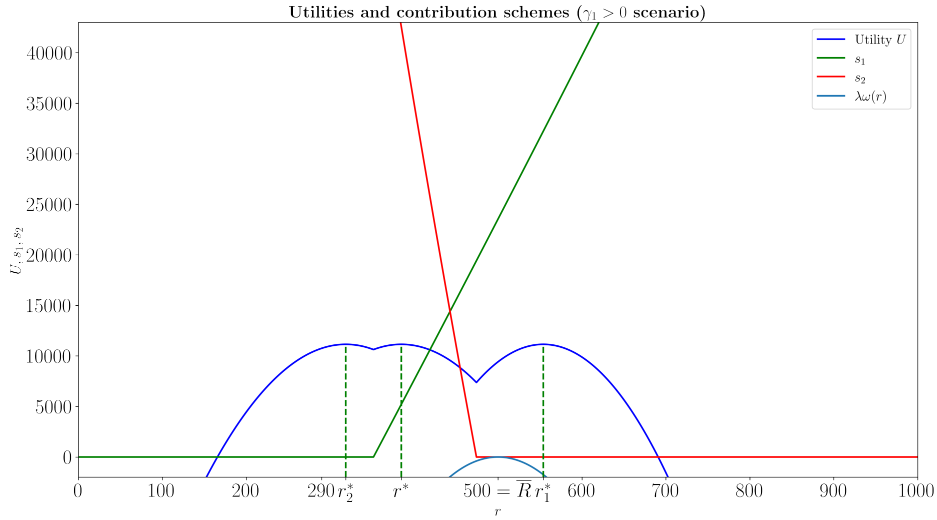

Figure 3.4: The parameters are $\overline{R} = 500, a = 2000, \rho_1 = 3, \rho_2 = 1, \lambda = 9/15$. The equilibrium policy turns out to be $r^* \approx 385$. Around the ideal policy $\overline{R} = 500$ one can see the weight term $\lambda\omega(r)$. The values of r_i^* are the optimal policy results if only firm i is in the game.

Rearranging the terms and using equation 3.13 the proposition is proven:

$$s_j(r_j^*) - s_j(r^*) = \pi_j(r_j^*) - \delta_j(r^*) - \pi_j(r^*) + \delta_j(r^*) = \pi_j(r_j^*) - \pi_j(r^*). \tag{3.23}$$

□

Assuming truthful Nash equilibria thus allows to explicitly compute the contribution schemes:

Doing this for the case $\gamma_1 > 0$, where the first firm will lobby *for* regulation measures, is indicated in Figure 3.4. The punishment term $\lambda\omega(r)$ – the squared distance to the ideal policy $\overline{R} = 500$ – is a downwardly opened parabula. Due to γ_1 being positive, we find by deriving equation 3.7 $\partial\pi_1^*/\partial r = \frac{2}{9}\gamma_i(a + r\gamma_i) > 0$, thus the first firm would benefit from a stricter regulation policy, thus—if it were the only firm to lobby— it would lobby for a policy $r_1^* > \overline{R}$. Factoring in the first firm contribution this contributes to the policy maker's objective function to have a local max of a parabula at r_1^*. It can be imagined that both of the contributions "bend" the squared distance term. Because $\gamma_2 < 0$, i.e. the second firm would lobby for a lower regulation, i.e. $r_2^* < \overline{R}$. The resulting ideal policy r^* is at around 385. It can be observed that this is between but not the average of the values r_1^* and r_2^* (or r^*), as the firms' contributions are skewed towards the 0. This is because even the first firm would have lower cost at 0 regulation, as the cost function is $(r/\rho_1)Q_1$.

The case $\gamma_1 < 0$ is illustrated in Figure 3.5. In this case, both $r_1^* and r_2^*$ are smaller than $\overline{R}$. And because both companies are contributing together to decrease regulation, the (global) policy equilibrium r^* is below both r_1^* and r_2^*. However, it can be noted that the green curve, the contribution of the first firm $s_1(r)$, goes below the curve of the second firm in red, as the second company would save more with a lower regulation regime and thus, due to the

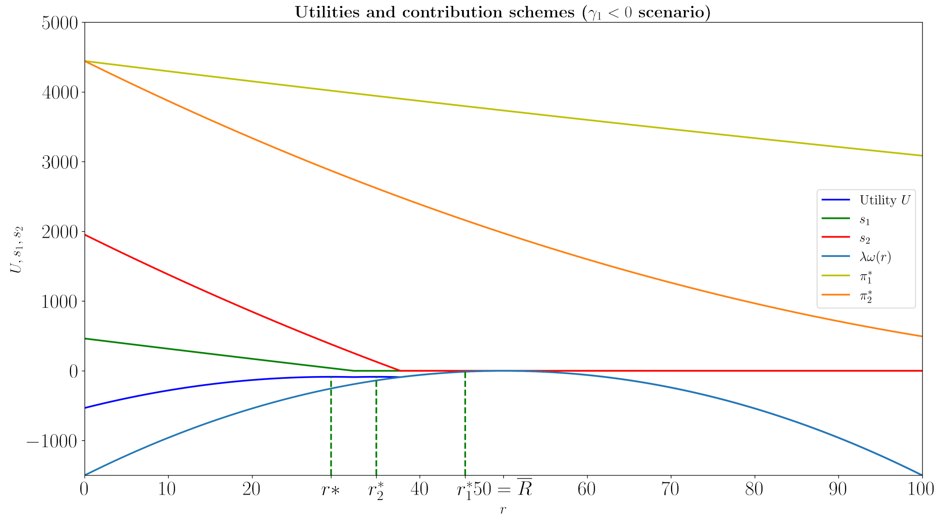

Figure 3.5: The parameters are $\overline{R} = 50, a = 200, \rho_1 = 1.5, \rho_2 = 1, \lambda = 9/15$. The equilibrium policy turns out to be $r^* \approx 385$. Around the ideal policy $\overline{R} = 500$ one can see the weight term $\lambda\omega(r)$. The values of r_i^* are the optimal policy results if only firm i is in the game.

truthful property of the Nash equilibrium, would contribute more towards a lower regulation as the *relative* not *absolute* profits are relevant.

The last figure (3.6) shows the degenerate case for when the ideal policy r^* would algebraically compute to a negative value. The second firm (with greatly higher adjustment costs) is spending a relatively large amount to let the policy maker deviate from the ideal policy $\overline{R} = 5$ to have no regulation at all. The green firm is still saving its $2/5$ share of the costs and thus does not spend enough to push the policy maker towards its ideal policy of $r_1^1 > 6$.

Note that the s_i are *quadratic* funtions in r, but in the numerical examples the coefficient of the linear term is very high, thus they may appear as linear functions in the last examples discussed.

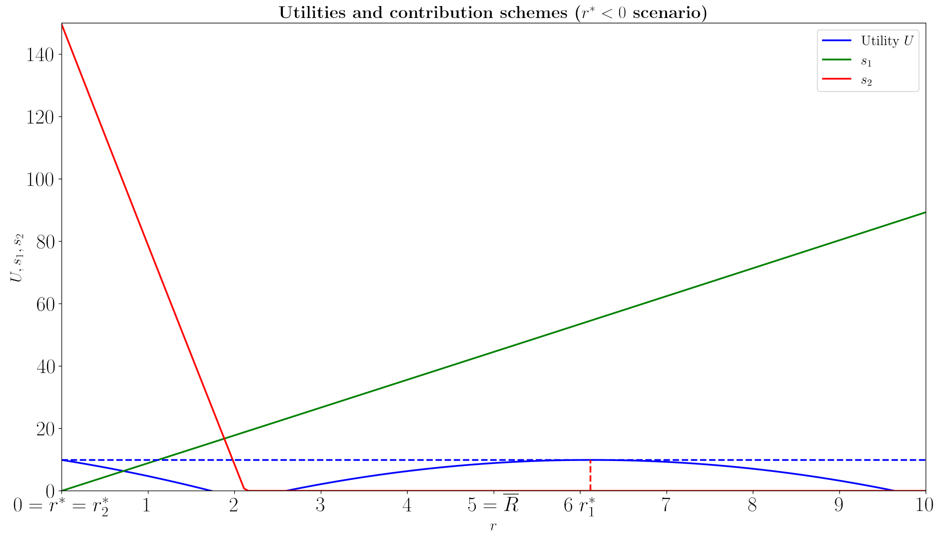

Figure 3.6: The parameters are $\overline{R} = 5, a = 200, \rho_1 = 5/2, \rho_2 = 1, \lambda = 8/10$. The equilibrium policy turns out to be $r^* = 0$, i.e. the absence of any regulation at all. The problem here is that the cost functions will be zero as well. Both companies produce 66 2/3 units at a profit of 4444 4/9. $U(r^*) \approx 9.91$.

3.2 Discussion

The model‘s main result (and the answer to the posed research question) thus is, that a company is lobbying *for* regulations iff. its relative advantage (γ) is positive. In the two company case this requires the green company to have twice as much green capital as the dirty company or, equivalently, half the marginal cost (or less).

Assume having N total firms, with M domestic firms in the set $\mathscr{M}$, possibly extended by $M - N$ foreign firms. Order them $\rho_1 > \rho_2 > \cdots > \rho_M$. It can then be shown that firm i is green (i.e. lobbies *for* regulation)

$$\Leftrightarrow \rho_i > \frac{N}{M-1} \frac{M-1}{\sum\limits_{j \in \mathscr{M} - \{i\}} \frac{1}{\rho_j}} =: \frac{N}{M-1} \rho_{-i}^{\mathscr{H}} . \tag{3.24}$$

where $\rho_{-i}^{\mathscr{H}}$ is the harmonic sum without firm i. The proof of this statement is like the computation done in the proof of Proposition 1 — just a bit more convoluted. The generalized relative advantages can then be read off as $\gamma_i^N = \sum_{j \neq i} \frac{1}{\rho_j} - \frac{N}{\rho_i}$, which is for $N = M = 2$ equivalent with the definition of γ_i from before. It can be seen that, for the company most green, and in the closed economy case ($N = M$) γ_1 is positive iff. $M \sum_{j \neq 1} \rho_j < \rho_1$. In words: the most green firm will lobby *for* climate measures precisely when its green capital is larger than the sum of the green capital of *all other* firms times the total number of companies. This would obviously lead to an explosive requirement for the green capital, i.e. an almost perfect cost efficiency in regards to regulation. The models thus predicts that only one domestic company (but all of the foreign[6] ones) lobby for climate regulations.

[6] Multinationals are not modeled in so far, even though they are part of the empirical analysis.

One major weakness of the model is the assumption of the truthfulness of the companies‘ contribution schemes. In reality, one would assume the policy maker to have *less* information than the companies, which would withhold the information and try to cash in additional profits.

The model also bases around the explicit assumption that the companies can lobby for a policy maker, say a political party, which would have a *fixed* “ideological” ideal policy $\overline{R}$. This does not capture the fact that there is divisiveness among parties themselves. In the case of a multi-party system, which is the case for many countries except the U.S., it is not clear how the companies would split their contributions to obtain a target policy as this scenario inherently spells “probability” due to the lack of information. Obviously, in the U.S. case one could view the Republican party to go for $\overline{R} = 0$ and the Democratic party to go for a $\overline{R}$ which roughly implements the Kyoto protocol, but in multi-party systems coalitions are forming and the $\overline{R}$ will be a result of negotations.

Furthermore, the weight factor λ is not determined empirically, but is likely rather high, because the weighting $1-\lambda$ of the impact of the companies‘ contributions is assumed to be rather low. This is because in reality, there are many sectors impacted by climate regulations due to increasing energy costs. Also, NGOs play a large role in environmental policies, they also work supranationally — but also not always together in their tactical choices (Hadden & Jasny, 2019, p. 654).

A strength of the model is its elegance and simplicity to show case the indirect effect of increasing regulation in terms of the market share.

4 Conclusion

The regulation lobby game (as presented in Kennard, 2020) delivers a solid microeconomic analysis of why firms could profit from increasing environmental regulation, i.e. due to shifts of the market in favour of environmental friendly companies. However, it fails the test of generalization to the multiple company setting as well as the reality check of typical companies‘ behaviour in the sense, that they would likely not spent excess profit completely in terms of donations.

Due to its simplicity, the model can be extended in various ways, such as making the ideal policy (of the policy maker) dependent on the households‘ income levels (cf. ibid., pp. 32–34 app.) or investments in energy efficiencies (ρ_i) (cf. ibid., pp. 35–38 app.)

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5 Appendix

Python program that takes as parameters $a, \rho_1, \rho_2, \overline{R}$ and λ to return the unique Nash equilibrium (proven to exist in Proposition 2 and with the formulas proven in the text) in the form of $s_1, s_2, r^*, U, \pi_1, \pi_2$.

```
def solve(a, rho_1, rho_2, R_ideal, lambd):
    R_max = max(100, 2*R_ideal)
    gamma_1 = 1 / rho_2 - 2 / rho_1
    gamma_2 = 1 / rho_1 - 2 / rho_2
    print("gamma_1: {} \t gamma_2: {}".format(gamma_1,
       gamma_2))

    if a <= R_max * (2 / rho_2 - 1/rho_1):
        print("a is set to small! Should be at least: {}".
           format(R_max * (2 / rho_2 - 1/rho_1)))

    if lambd <= (gamma_1**2 + gamma_2**2) / (9 + gamma_1**2 +
        gamma_2**2):
        print("Warning: lambda is under the treshold for Nash
           -equilibria uniqueness!")

    beta = lambd / (1 - lambd)
    beta_inv = (1 - lambd) / lambd

    r_star = (R_ideal + 1/9 * a * beta_inv*(gamma_1 + gamma_2
       )) / (1 - 1/9 * beta_inv * (gamma_1**2 + gamma_2**2))
    if r_star > R_max:
        print("r^* over the limit!")
        r_star = R_max
    if r_star < 0:
        print("r^* negative!")
        r_star = 0
```

```python
r_1 = max(0, (R_ideal + 1/9 * a * beta_inv*(gamma_1)) /
    (1 - 1/9 * beta_inv * (gamma_1**2)))
r_1 = min(R_max, r_1)
r_2 = max(0, (R_ideal + 1/9 * a * beta_inv*(gamma_2)) /
    (1 - 1/9 * beta_inv * (gamma_2**2)))
r_2 = min(R_max, r_2)
print("r_star: {} \t r_1: {} \t r_2: {}".format(r_star,
    r_1, r_2))

q_1 = 1/3 * (a + r_star * gamma_1)
q_2 = 1/3 * (a + r_star * gamma_2)
print("Q_1*: {} \t Q_2*: {}".format(q_1, q_2))
print("pi_1*: {} \t pi_2*: {}".format(q_1**2, q_2**2))
pi_1 = lambda r: 1/9 * (a + r * gamma_1)**2
pi_2 = lambda r: 1/9 * (a + r * gamma_2)**2


s_1_rstar = max(0, beta*((R_ideal - r_star)**2 - (R_ideal
     - r_2)**2) +  pi_2(r_2) - q_2**2)
s_2_rstar = max(0, beta*((R_ideal - r_star)**2 - (R_ideal
     - r_1)**2) +  pi_1(r_1) - q_1**2)

s_1 = lambda r: max(0, 1/9 * (a + r * gamma_1)**2 - q_1
    **2 + s_1_rstar)
s_2 = lambda r: max(0, 1/9 * (a + r * gamma_2)**2 - q_2
    **2 + s_2_rstar)
U =   lambda r: -lambd*(R_ideal - r)**2 + (1 - lambd)*(
    s_1(r) + s_2(r))
print("Utility {}".format(U(r_star)))

return s_1, s_2, r_star, U, pi_1, pi_2
```