Salience, Consequences and Equal Sharing in Partnerships

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To my family

Preface

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Introduction

This thesis consists of three separate and self-contained papers. Chapter 1 is co-authored by Marc Möller and Chapter 3 is joint work with Ann-Kathrin Crede and Jonas Gehrlein. While the first two chapters apply microeconomic theory, the third chapter presents the design of an experimental study.

Although individual chapters are rather different with respect to the precise research question, there exist certain themes they have in common. Theoretical findings give us advice on how to optimally act when facing heterogeneous agents. However, we often observe less sophistication in reality. Monopolists use price discrimination less than expected, while equal sharing can be observed in teams surprisingly often. In the first two chapters, I consider these two puzzles. Chapter 1 shows how equal shares can be optimal for team surplus when there are asymmetric information and project selection, even in the presence of considerable heterogeneity. Chapter 2 provides a rationale for the prevalence of pooling of heterogeneous consumers by considering consumers who focus on salient attributes.

In Chapter 2, consumers with salience-driven preferences consider two attributes in their decision, the quality and the price of a product. In Chapter 3, we also consider individuals who focus on salient attributes. However, the two attributes of a decision are the consequences and the moral cost of an action.

Chapter 1 provides a rationale for equal revenue-sharing in heterogeneous partnerships. We introduce project choice and information sharing to a standard team production setting. A team with two agents can choose whether to work on a status quo project or on an alternative project. While the alternative's quality is commonly known, the status quo project can have high or low quality with equal probability. If both agents receive information about the quality of the status quo project, it would be optimal for team surplus to give a higher share to the more productive agent. However, we consider the case when only one of the agents receives information. The information is verifiable and an informed agent can choose whether to disclose this information to the partner. Disclosing information yields the benefit of better adaptation but might also demotivate the partner, if he expected a higher quality when receiving no information. It turns out that it would be optimal for information sharing, in the sense that it maximizes the probability of full information sharing, if we give a higher share to the less productive agent. We characterize the optimal sharing rule in situations in which inducing full information sharing is feasible. Equal revenue-sharing strikes a balance between the two objectives of adaptation and motivation and can be efficient even in the presence of considerable productivity differences across partners.

Chapter 2 generalizes the price discrimination framework of Mussa and Rosen (1978) by considering salience-driven consumer preferences in the sense of Bordalo et al. (2013b). Consumers with salience-driven preferences give a higher weight to attributes that vary more. When restricted to offering two products to heterogeneous consumers, it turns out that the monopolist can only separate with products that let consumers focus on the price. Since focussing on price reduces the willingness to pay of consumers, profits from separation decrease compared to the benchmark when consumers have standard preferences. In contrast, the alternative strategies of pooling or excluding low types become more profitable, since it is always possible to additionally offer a decoy that lets consumers focus on quality. Salience thus reduces the monopolist's propensity to separate different types of consumers. I characterize the conditions under which the monopolist induces consumers to focus on quality rather than on price. Quality is salient in a market whenever the heterogeneity is low and the share of high types is low or when heterogeneity is high and the share of low types is high.

The result that the monopolist is less likely to separate generalizes to the case when the monopolist is not restricted in the number of products he can offer, but there are non-zero development costs of decoys. It is then always possible to find enough decoys such that quality becomes salient while separating. However, as long as there are some development costs, separation is relatively less attractive than in the case of consumers with standard preferences.

Chapter 3 contributes to the long ongoing debate on whether interaction in a market influences moral decisions of individuals. While some studies show that individuals tend to decide less morally when being exposed to a market environment, other studies argue that the experience of market interaction promotes moral behavior. We add to this discussion by distinguishing between two moral concepts: consequentialism and deontology. According to consequentialism, actions are evaluated only by their consequences. Contrary to that, deontology focuses solely on the morality of the action itself. Evidence shows that whether individuals behave according to consequentialism or according to deontology depends on the context. Furthermore, individuals often consider both, the consequences and the moral cost of an action, when taking moral decisions.

We hypothesize that participants are more likely to take decisions according to consequentialism if they interacted in a market before. This hypothesis is based on the assumption that market interactions make cost-benefit considerations more salient, which increases the weight that consequences get in the decision. Individuals who consider consequences *and* moral cost are then torn towards more consequentialist decisions. Since it has been shown that moral decision making is moderated by emotions, we expect that the attitude towards markets moderates the effect.

We design an online experiment in order to investigate the effect of market interaction on moral decision making in a subsequent moral dilemma. In the first stage, participants are randomly assigned either to a market game or to a non-market game. The market game consists of a double auction, which lets participants experience a typical market environment with competition, interaction, market framing and cost-benefit considerations. The non-market game is a lottery which is designed such that the payoff distribution is equal to the distribution in the double auction, but there is neither competition nor interaction, market framing or cost-benefit considerations. In the second stage, participants face a hypothetical moral trolley dilemma, in which they have to decide whether they would be willing to kill one person in order to save three. While the consequentialist decision would be to sacrifice the person, deontological principals would not allow to actively sacrifice this person. In order to elicit the attitude towards markets, we use the Fair Market Ideology scale of Jost et al. (2003) in a subsequent questionnaire. The experiment will be conducted on Amazon Mechanical Turk.

Chapter 1

Partnerships with Asymmetric Information: On the Benefits of Equal Sharing amongst Unequals

joint with Marc Möller

1.1 Introduction

Evidence shows that teams are often organized as partnerships, i.e. team members work together on a project and share the revenue. Partnerships can for example be found in service professions (Hansmann, 1996) as law firms (Leibowitz and Tollison, 1980), medical practices (Encinosa et al., 2007), architecture firms and accounting firms (Greenwood and Empson, 2003).

If the partners share the revenue, free-riding leads to inefficiently low effort provision since each partner only considers his own share of revenue. Experimental evidence for such free-riding can be found in Nalbantian and Schotter (1997) and Chao and Croson (2013). In case of heterogeneous partners, this free-riding problem can be mitigated by giving higher shares to more productive partners. This result is quite robust and also holds if partners differ in ability and self-select (McAfee and McMillan, 1991) or when production is of repeated nature (Rayo, 2007; Kobayashi et al., 2016).

However, we often observe equal revenue sharing even in partnerships in which we would expect heterogeneity.[1] Encinosa et al. (2007) find that 54% of small medical-group practices (3 to 5 members) share equally. In larger practices (16 to 24 members), equal sharing still plays an important role (24%). Farrell and Scotchmer (1988) find equal shares among partners of similar seniority in law firms and argue that for example marriage and coauthorship in economics are close to equal sharing.[2]

Such equal sharing in partnerships can be rationalized e.g. by preferences for equality (Bartling and von Siemens, 2010; Gill and Stone, 2015), concerns for sabotage (Bose et al., 2010) or market reputation and moral hazard (Jeon, 1996). Farrell and Scotchmer (1988) argue that equal sharing is a social convention and people want to satisfy some concept of justice. However, evidence suggests that it might actually be teamwork that leads to preferences for equal sharing in the first place (Hamann et al., 2011).

[1]Prat (2002) provides arguments in favor of heterogeneity in a team theory setting à la Marschak and Radner (1972).

[2]Ray and Robson (2018) suggest to randomize the order of the names in economic coauthorship, which is a further step towards equal sharing.

Furthermore, discussions about how revenue should be shared, if not equally, could give rise to inefficient rent-seeking.

We show in this paper that in a standard team production setting à la Holmström (1982) with project quality and effort being complementary inputs, equal sharing can be optimal for heterogeneous agents if we introduce team project choice and asymmetric information about projects' qualities. The changes we incorporate in the standard model can be justified by observations in reality. In partnerships, agents do often not only work together but also decide which project they want to work on. This seems natural when considering firms or countries working together. Within organizations, the share of self-managed teams has increased in recent years (Lazear and Shaw, 2007; Osterman, 2000; Manz and Sims Jr, 1993).

Consider for example a team that is organizing an event and wants to book a newcomer band. The band's quality is uncertain but the team expects it to be better, and hence attract more people, than the alternative of a well-known local artist. However, one of the partners in the organizing team might get "bad news" about the quality, as e.g. that the last concert of the band was a flop. If he reveals this information to the team, they can adapt to the alternative, which is known to have higher quality in the presence of such "bad news".

The possibility to disclose information and the project choice introduce a trade-off between improving adaptation and motivating effort. The disclosure of information allows the team to choose a better project. However, it also demotivates the partners if the information is "bad news". In order to study this trade-off, we use a similar model of team production as Blanes i Vidal and Möller (2016). We consider a team which consists of two agents. They can jointly choose between two projects. Before they decide on a project, one of them might receive private information about the quality of the projects. Information is private but verifiable, so an informed agent can credibly disclose the news to his partner. When an informed agent decides whether to disclose, he compares the benefit from better adaptation to a potential loss of his partner's motivation. A loss of motivation can occur if the news is bad in the sense that the partner's expectation about quality was higher without information. Since the informed agent only takes into account his own share of revenue, his disclosure strategy might not be optimal for team surplus. By carefully choosing the revenue sharing rule, we do not only affect motivation but also whether agents disclose their information. While Blanes i Vidal and Möller (2016) find the optimal mechanism for homogeneous agents, we consider heterogeneous agents and restrict attention to the case in which shares are independent of revenue and disclosure strategies.

In the benchmark of project selection with symmetric information, the expected surplus of the team is maximized if the more productive agent receives a higher share. The percentage loss in surplus if shares are equal rather than optimal can be substantial, up to 25%.

If we introduce asymmetric information, we have to take into account the impact of the revenue sharing rule not only on the effort but also on whether agents disclose private information. Given the optimal sharing rule in the benchmark case, the less productive agent is less willing to disclose because the reaction of the more productive agent on changes in expected quality is stronger. Increasing the share of the less productive agent and thereby decreasing the share of the more productive agent reduces this reaction and thus makes it more likely that the less productive agent is willing to disclose. It turns out that the propensity to share information in the team is maximized if the shares are just opposite to the shares in the benchmark with symmetric information: The less productive agent needs a higher share while the more productive agent gets a lower share. Compared to the optimal sharing rule with symmetric information, giving a higher share to the less productive agent can increase surplus since better information sharing leads to better adaptation.

Our main result characterizes the optimal sharing rule in situations in which full disclosure is feasible. The optimal sharing rule balances incentives to disclose information and incentives to provide effort and thus lies between the optimal information sharing rule and the optimal sharing rule given symmetric information. Hence, the optimal sharing rule is torn towards equal shares and it turns out that there exist situations in which sharing equally amongst unequals is optimal for the partnership even in the presence of considerable heterogeneity. Where we can determine the optimal sharing rule, the percentage loss in surplus due to equal sharing is weakly lower than in the benchmark case.

The rest of the paper is structured as follows. Section 1.2 reviews the literature on equal sharing and information problems in teams. Section 1.3 sets up the model of team production with project choice. In Section 1.4, we consider the benchmark of symmetric information. In Section 1.5, we introduce asymmetric information and consider the effect of the sharing rule on disclosure strategies. In Section 1.6, we characterize the optimal sharing rule and discuss the optimality of equal sharing. Section 1.7 examines the robustness of the model and Section 1.8 concludes.

1.2 Literature

In partnerships, the problem of free-riding can be mitigated by carefully designing the sharing rule (Legros and Matthews, 1993). There are several papers providing arguments against equal sharing. If a partnership forms endogenously, equal revenue sharing leads to partnerships that are too small (Farrell and Scotchmer, 1988) and not diverse enough (Sherstyuk, 1998). Wilson (1968) shows that equal sharing is not optimal when agents are heterogeneous in risk preferences. Kräkel and Steiner (2001) adapt the LEN framework of the standard principal-agent model to partnerships. They show that equal sharing is not optimal even if agents are homogeneous. While equal sharing would induce optimal risk-sharing, optimal motivation pushes the shares towards giving each agent his own profit. Balancing risk-sharing and motivation, they find that the optimal shares lie between equal sharing and no sharing (keeping the own profits). Equal sharing would only be optimal in the extreme case of variance or risk aversion going to infinity. Similarly, Winter (2004) shows that equal sharing is typically not optimal even for homogeneous agents in the presence of complementarities in efforts and asymmetric information about efforts.

Nevertheless, as mentioned in the introduction, we often observe equal sharing in reality and equal shares are assumed in many papers considering partnerships (e.g. Huck and Rey-Biel, 2006; Farrell and Scotchmer, 1988; Levin and Tadelis, 2005). The authors typically argue that equal shares are a social convention or there is a social preference of agents (Farrell and Scotchmer, 1988). Theoretically, it has been shown that equal shares can be optimal in order to foreclose sabotage (Bose et al., 2010) or if there are market reputation and moral hazard (Jeon, 1996). Bose et al. (2010) show that agents would sabotage each other if the principal cannot commit to a reward structure ex-ante. Hence, the possibility to commit to equal shares could be beneficial for the principal because agents would not sabotage each other. They argue that equal sharing is the only distribution to which the principal could commit since this commitment is facilitated by legal obligations. Bevia and Corchón (2006) also find that sabotage is rational in cooperative production when revenue is shared among the agents. Even though a saboteur suffers from lower revenue, he benefits from a better relative standing. Such sabotage is more likely under meritocratic systems than under equal sharing. Jeon (1996) consider a model with two periods in which the effort in the first period signals higher ability and thus increases the wage in the second period. It turns out that when the sharing arrangement is such that revenue from abilities is shared, equal sharing is efficient. Furthermore, social preferences as inequality aversion, make equal shares more attractive. Bartling and von Siemens (2010) show that if agents are sufficiently inequality averse, equal shares are the only renegotiation proof option. We provide an argument in favor of equal sharing in a simple team setting.

In our model, we find a force driving in the direction of equal shares when introducing asymmetric information and project selection. Information is private but can be shared with the partners. We thus also relate to the literature on teams and information sharing. In this literature, information sharing would typically be optimal for surplus but teams fail to share information because of conflicting preferences (Li et al., 2001; Dessein, 2007), career concerns (Ottaviani and Sørensen, 2001; Levy, 2007; Visser and Swank, 2007) or distortions by voting rules (Feddersen and Pesendorfer, 1996). In some settings, however, restricting information about the quality of a project is beneficial because it mitigates the free-riding problem in team production. In Teoh (1997), the social planner can restrict access to information ex-ante in a public goods game. This is optimal if “bad news” decrease contributions more than “good news” would increase them. Hermalin (1998) only informs one agent who can then exert effort first. The possibility of leading by example increases the informed agent’s effort above the optimal free-riding effort. Similarly, in our paper, full information sharing is not necessarily optimal. It has the positive effect of better adaptation and the negative effect of demotivating team members. Agents possibly fail to share information because it can be optimal to keep the other agent motivated, rather than realistic.

This trade-off between adaptation and motivation is considered in some other papers. Banal-Estañol and Seldeslachts (2011) study merger decisions and the incentives to free-ride on a partner’s post-merger decision. Zábojník (2002), Blanes i Vidal and Möller (2007), and Landier et al. (2009) consider the trade-off in settings in which decision making and execution of effort lie at different hierarchical levels. Zábojník (2002) shows that in case of liquidity constraints and thus limited punishment possibilities, it might be optimal to delegate the decision to the worker in order to keep his motivation high. Landier et al. (2009) find that dissent in the preferences of the decision maker and the implementer can be beneficial since it implies a better use of information. This results in better adaptation and higher credibility of the decision maker but also demotivates the implementer. Blanes i Vidal and Möller (2007) ask whether a worker should get hard information given a leader has additional soft information. Giving a worker hard information might induce the leader to give a too high weight to this hard information in order to avoid demotivating the worker. These studies consider decision making and implementation at different hierarchical levels. We contribute to this literature by considering agents who take decisions and implement projects jointly.

Similarly, Guo and Roesler (2016) consider the trade-off between adaptation and motivation in a dynamic setting with two agents working together on a project. Agents' efforts increase the success probability of the project. While working on the project, an agent might receive private information about the success probability. He can then either exit the project and thereby disclose his information or he can stick to the project and shirk on the other agent's effort. However, Guo and Roesler (2016) consider homogeneous agents who share equally and focus on the effort and exit decisions in equilibrium.

Campbell et al. (2014) and Gershkov and Szentes (2009) also consider teams with private information and group members who may not share their information in order to manipulate beliefs about the marginal return of effort. Their settings differ from ours since their agents provide effort in order to acquire information rather than for the implementation of a joint project.

Our paper adds information sharing in the same way as Blanes i Vidal and Möller (2016). They introduce asymmetric information about the production technology and information sharing into a model of team production. They use a mechanism design approach and consider homogeneous agents. But team members, whether they are different firms or different workers, are often heterogeneous. Given heterogeneous agents, we restrict attention to partnerships, i.e. team members share the revenue of the project.

Gershkov et al. (2016) take a similar approach when introducing asymmetric information in a team production setting with moral hazard. However, they assume that revenue distribution can depend on a signal about the ranking of efforts. They find a simple rank-based contract which can implement first best information sharing and first best efforts given homogeneous agents in many situations. With heterogeneous agents, first best is possible if private information is given to one agent only. Without the ranking of efforts, we find that there is no revenue distribution which implements first best information sharing and effort choices. In order to minimize free-riding, we would want to give a higher share to more productive agents. However, the need to incentivize information sharing promotes giving a higher share to less productive agents.

Our result thus provides a rationale for why sometimes equal shares could be preferred given heterogeneous agents: If transfers cannot depend on the disclosure strategy, information sharing has to be incentivized by the choice of the shares. Since equal shares always lie between the optimal shares given symmetric information and the optimal shares for information sharing, trying to balance the incentives to provide effort and to share information leads us in the direction of equal shares.

1.3 Model

Consider a team that consists of two agents $i = L, H$, who work on a joint project X. The revenue of the project depends on whether it is successful or not. A successful project yields revenue 1 while a failed project generates no revenue. The probability of success of a project depends on the efforts of the agents, e_L and e_H, on the productivities of their effort, γ_L and γ_H, and on the quality of the project, which, with slight abuse of notation, we also denote as X:

$$R_X(e_L, e_H) = (e_L\gamma_L + e_H\gamma_H)X. \tag{1}$$

Since revenue in case of success is equal to 1, $R_X(e_L, e_H)$ is equivalent to the expected revenue of a project X. Agents are heterogeneous in the sense that the effort of agent H is more productive $\gamma_L < \gamma_H \leq 1$. If the project is successful, the revenue is shared between the two agents according to the sharing rule $\boldsymbol{\alpha} = (\alpha_L, \alpha_H)$ with $\alpha_L + \alpha_H = 1$.[3] Effort is not contractible. Effort costs $C(e_i)$ are increasing at an increasing rate for both agents $i = L, H$:

$$C(e_i) = \frac{1}{2}e_i^2. \tag{2}$$

[3]Since revenue is always either 0 or 1, the sharing rule cannot depend on revenue. Another argument for the sharing rule being independent of revenue would be that team revenue is not verifiable by a third party. Furthermore, the sharing rule cannot depend on the probability of success, since it cannot be observed. Such linear contracts are "particularly suitable for organizations in which individual goals coincide: partnerships, political parties, NGOs." (Blanes i Vidal and Möller, 2007)

Hence, agents differ only in their effort productivity.[4] Agents choose effort in order to maximize their expected utility, which consists of their share of the expected revenue minus their costs of effort:

$$U_i = \alpha_i R_X(e_L, e_H) - C(e_i), \qquad i = L, H. \tag{3}$$

Total expected surplus of a project with quality X is the sum of agents' expected utilities. It is thus the total expected revenue of the project, reduced by the costs of effort of the two team members:

$$S_X(e_L, e_H) = R_X(e_L, e_H) - C(e_L) - C(e_H). \tag{4}$$

Efficiency would require that marginal revenue equals marginal cost for each agent $i = L, H$:

$$R'_{e_i}(e_L, e_H) = C'(e_i). \tag{5}$$

It is, however, a standard result that team production leads to inefficient effort provision (Holmström, 1982). To see this, consider the first order condition of an agent's utility maximization problem:

$$\alpha_i R'_{e_i}(e_L, e_H) = C'(e_i). \tag{6}$$

Since $\alpha_i \leq 1$ with strict inequality for at least one of the agents, marginal cost must remain at a lower level than efficient. At least one of the agents will thus choose an inefficiently low effort. They only take into account their own share of the revenue and ignore the impact of their effort on their partner's utility. Given the specific functions for effort costs and revenue, agents $i = L, H$ choose efforts which maximize their utility:

$$e_i^* = \alpha_i \gamma_i \hat{E}_i[X], \tag{7}$$

where $\hat{E}_i[X]$ is agent i's expectation of quality X.

We consider the situation of a team working on a status quo project Q which can have either low quality $Q = q$ or high quality $Q = 1 > q$. It is

[4] The model is equivalent to a model in which agents have equal effort productivity but differ in their costs with $C(e_i) = \frac{1}{2\gamma_i^2} e_i^2$.

common knowledge that the states are equally likely ex-ante and hence the ex-ante expected quality is $E[Q] = \frac{1+q}{2}$. Conditional on the quality of the status quo project Q being low, one of the agents will receive private and verifiable information.[5] Since information is verifiable, the informed agent can choose to disclose this new information to his partner. After the decision of disclosing potential evidence, the team chooses whether to stick to the status quo project Q or whether to switch to an alternative project P with quality P.[6] We abstract from a specific voting procedure and use the rule that the team switches to alternative P if and only if evidence was disclosed. We show at the end of Section 1.5.3 that this rule can be rationalized as the outcome of an arbitrary voting procedure.

We assume that project Q has a higher ex-ante expected quality than project P. However, project P would be preferred to project Q if project Q is known to be of low quality.

Assumption 1 (Status quo vs. alternative project)**.** $P \in (q, E[Q])$.

This assumption brings us to the interesting case in which project Q is preferred ex-ante and project P would be preferred in case of evidence for the low quality of project Q. It would thus be beneficial for the team to adopt project P in case of receiving evidence. Note that for all relevant expectations $q \leq \hat{E}_i[X] \leq 1$, optimal efforts are such that the probability of success $R_X(e_L, e_H)$ is well defined in $[0, 1]$.

To summarize, the timing is as follows: First, nature decides whether the quality of project Q is high or low. If quality is low, there is evidence which is observed by one of the agents. Second, an informed agent can decide whether to disclose the information to his partner. Third, agents jointly choose whether to switch to project P and forth, each agent contributes

[5]The assumption that there is information only if the quality of project Q is low simplifies the analysis but is not crucial for the result that optimal information sharing requires giving a higher share to the less productive agent. Similarly, allowing that both or none of the agents receives information does not change this result. We will discuss this in Section 1.7.1.

[6]If there was uncertainty about the quality of project P, the analysis would be analogous, with P replaced by $E[P]$.

with effort to the success of the chosen project. Finally, nature determines whether the project is successful, in which case the revenue is shared among the agents according to the sharing rule $\boldsymbol{\alpha}$.

We assume that the sharing rule is independent of the choice of the project $X \in \{Q, P\}$ and of the disclosure history $D \in \{0, L, H\}$.

Assumption 2 (Simple revenue sharing)**.** $\boldsymbol{\alpha}(X, D)$ *is independent of* $X \in \{Q, P\}$ *and* $D \in \{0, L, H\}$.

Rewarding the disclosure of information would provide incentives to disclose information (Blanes i Vidal and Möller, 2016). However, we focus on the problem of a social planner when he has to incentivize efforts and disclosure with a simple revenue sharing rule.

We use the equilibrium concept of Perfect Bayesian Equilibrium, i.e. beliefs are consistent given strategies on the equilibrium path and strategies are sequentially rational given beliefs.

1.4 Benchmark: Symmetric information

As a benchmark, consider the situation of symmetric information: If the quality of project Q is low, both agents receive evidence. The disclosure strategies are thus irrelevant in this benchmark case. Agents will agree to choose the project with the higher expected quality. Therefore, they stick to the status quo project Q if there is no evidence and change to the alternative project P else. Total expected surplus in this situation is

$$E^{sym}[S(\boldsymbol{\alpha})] = \frac{1}{2}S_1(e_L^*(1), e_H^*(1)) + \frac{1}{2}S_P(e_L^*(P), e_H^*(P)). \tag{8}$$

Maximizing expected surplus (8) given individually optimal effort choices, we find the optimal shares α_L^{sym} and α_H^{sym} and characterize them in Proposition 1.1:

Proposition 1.1 (Optimal shares with symmetric information)**.** *In the symmetric information benchmark, the surplus-maximizing shares are*

$$\alpha_L^{sym} = \frac{\gamma_L^2}{\gamma_L^2 + \gamma_H^2} \quad \textit{and} \quad \alpha_H^{sym} = \frac{\gamma_H^2}{\gamma_L^2 + \gamma_H^2}. \tag{9}$$

The more productive agent receives a higher share $\alpha_H^{sym} > \frac{1}{2}$.

The proof can be found in the Appendix. In the situation of moral hazard and symmetric information, it is surplus-maximizing to give a higher share to the more productive agent H than to the less productive agent L, since the team benefits more from agent H's effort. This implies that it is optimal to let the more productive agent work harder. He works harder not only because his effort is more productive but also because he gets more than half of the project's revenue.

As argued in the Introduction, we often observe equal sharing $\boldsymbol{\alpha}^{equal} \equiv (\frac{1}{2}, \frac{1}{2})$ even in the presence of different productivities. In our setting with symmetric information, equal sharing leads to a loss in surplus relative to the optimal shares $\boldsymbol{\alpha}^{sym}$:

$$\Delta E^{sym}[S] = \frac{E^{sym}[S(\boldsymbol{\alpha}^{sym})] - E^{sym}[S(\boldsymbol{\alpha}^{equal})]}{E^{sym}[S(\boldsymbol{\alpha}^{sym})]} = \frac{(\gamma_H^2 - \gamma_L^2)^2}{4(\gamma_H^4 + \gamma_H^2\gamma_L^2 + \gamma_L^4)} > 0. \tag{10}$$

The percentage loss in surplus increases in the heterogeneity of agents, i.e. it increases in γ_H and decreases in γ_L. It can amount to 25% for $\gamma_L \to 0$ and $\gamma_H \to 1$.

1.5 Information sharing

We now consider the case when, conditional on quality of project Q being low, only one of the agents receives evidence. Hence, the disclosure strategies of agents become relevant. In this section, we first determine the optimal revenue shares given disclosure strategies. Then, we show how the individually optimal disclosure strategies depend on the revenue sharing rule and find the sharing rule that optimizes information sharing in the sense that the propensity of full disclosure is maximized. Finally, we characterize the surplus-maximizing sharing rule under the constraint of full disclosure.

1.5.1 Optimal sharing given disclosure strategies

We showed before that with symmetric information, it would be optimal to reduce free-riding with the distribution $\boldsymbol{\alpha}^{sym}$. It turns out that the same distribution is optimal if there is asymmetric information and both agents choose the same disclosure strategy $d_L = d_H$.

Given project X, agents choose their efforts to maximize utility, i.e. according to (7). The effort of agent i depends on his expectation about the quality of the project. Since agents might have asymmetric information, their expectations about the quality of project Q may differ. An informed agent knows that the quality of project Q is low. Whenever an agent i remains uninformed, he updates his belief about the quality of project Q. He knows that with ex-ante probability $\frac{1}{2}$, quality is high and both agents remained uninformed. However, with ex-ante probability $\frac{1}{2}$, quality is low and the other agent was informed but conceals this information. The uninformed agent i updates his belief on whether project Q has high quality to

$$\rho_i = \frac{\frac{1}{2}}{\frac{1}{4}(1-d_j)+\frac{1}{2}} = \frac{2}{3-d_j} \geq \frac{1}{2}, \tag{11}$$

where $d_j \in [0,1]$ is the (equilibrium) probability that the other agent j discloses information given he receives evidence. Receiving no evidence and no information of the other agent increases the belief that project Q has high quality. Given the updated belief, agent i expects the quality of project Q to be

$$\hat{E}_i[Q] = \frac{1-d_j}{3-d_j}q + \frac{2}{3-d_j}. \tag{12}$$

The expected quality of project Q with updated beliefs is higher than its ex-ante expected quality since a higher weight is given to the high quality state. Since the quality of project P is not affected by the information, project Q is now even more attractive than ex-ante.

Taking the disclosure strategies d_L and d_H as given, the ex-ante expected surplus must take into account several cases. With probability $\frac{1}{4}$ the quality of project Q is low and agent i gets information. If agent i receives information, he discloses it with probability d_i to his uninformed partner j. Project P is then chosen and both agents know the quality of the project. With probability $(1-d_i)$, the informed agent does not disclose, so project Q is chosen. While the informed agent i knows that the quality of the project is low, the uninformed agent j updates beliefs to $\hat{E}_j[Q]$. Finally, with probability $\frac{1}{2}$, the quality of project Q is high, agents are not informed and will both update beliefs. The choice of project Q is optimal in this case. Considering all these cases, the ex-ante expected surplus is

$$\begin{aligned} E[S(\boldsymbol{\alpha}, d_L, d_H)] = & \\ & \frac{1}{4}[d_L S_P(e_L^*(P), e_H^*(P)) + (1-d_L)S_q(e_L^*(q), e_H^*(\hat{E}_H[Q]))] \\ & + \frac{1}{4}[d_H S_P(e_L^*(P), e_H^*(P)) + (1-d_H)S_q(e_L^*(\hat{E}_L[Q]), e_H^*(q))] \\ & + \frac{1}{2}S_1(e_L^*(\hat{E}_L[Q]), e_H^*(\hat{E}_H[Q])). \end{aligned} \tag{13}$$

This surplus is maximized by the sharing rule $\boldsymbol{\alpha}^*(d_L, d_H)$, characterized in Proposition 1.2.

Proposition 1.2 (Optimal sharing given disclosure strategies)**.** *The surplus-maximizing sharing rule given disclosure strategies d_L and d_H is*

$$\alpha_L^*(d_L, d_H) = \frac{\gamma_L^2 \hat{q}_L}{\gamma_L^2 \hat{q}_L + \gamma_H^2 \hat{q}_H} \quad \text{and} \quad \alpha_H^*(d_L, d_H) = \frac{\gamma_H^2 \hat{q}_H}{\gamma_H^2 \hat{q}_H + \gamma_L^2 \hat{q}_L}, \tag{14}$$

with

$$\hat{q}_i = \frac{1}{4}\left\{(d_i + d_{-i})P^2 + (1-d_i)q^2 + [(1-d_{-i})q + 2]\hat{E}_i[Q]\right\}, \quad i = L, H. \tag{15}$$

The less productive agent receives a higher share if and only if heterogeneity is not too strong $\gamma_L^2 \geq \gamma_H^2 \frac{\hat{q}_H}{\hat{q}_L}$.

The proof is in the Appendix. For given disclosure strategies d_H and d_L, we can determine the optimal distribution of revenue. Whenever both agents choose the same disclosure strategy $d_H = d_L$, the same sharing rule $\boldsymbol{\alpha}^{sym}$ as in the case of symmetric information is optimal. The reason is that even though agents do not have symmetric expectations in every situation, they have ex-ante the same expectation about what situations can arise. It is then surplus-maximizing to give a higher share to the more productive agent. Whenever agents differ in their disclosure strategies, the sharing rule $\boldsymbol{\alpha}^{sym}$ is not optimal anymore. The optimal share for an agent decreases in his own probability of disclosing and increases in the probability of disclosing of the other agent. Hence, the optimal share of the less productive agent $\alpha_L^*(d_L, d_H)$ is higher than α_L^{sym} whenever $d_L < d_H$. The less productive agent might even get a higher share than the more productive agent if his effort productivity is high enough.

If we want to find the overall optimal shares, however, we have to take into account that disclosure strategies depend on the sharing rule and are chosen by the agents to maximize their expected utility. Therefore, we will now look at the individually rational disclosure strategies of the agents.

1.5.2 Disclosure strategies

When an agent decides whether to disclose information or not, he has to anticipate which project will be chosen and which efforts will be provided by himself and his partner.

Project P is chosen if and only if information was disclosed. Therefore, agent i discloses information if he expects a higher utility from project P than if he conceals and the team sticks to the status quo project Q:

$$E_i[U_i^d] \geq E_i[U_i^c] \tag{16}$$

$$\Leftrightarrow \alpha_i[e_i^*(P)\gamma_i + e_j^*(q)\gamma_j]P - \frac{1}{2}e_i^*(P)^2 \geq \alpha_i[e_i^*(q)\gamma_i + e_j^*(\hat{E}_j[Q])\gamma_j]q - \frac{1}{2}e_i^*(q)^2.$$

If agent i discloses, the team will choose project P and efforts will be individually optimal given quality P. After concealing, project Q is chosen. While agent i then knows that the quality of project Q is low, agent j has to form expectations. As shown before, his expectation $\hat{E}_j[Q]$, given by (12), is higher than the quality of project P, so the uninformed agent would be more motivated when the informed agent did not disclose and they work on project Q.

Agent i discloses information if and only if the gain in project's quality due to switching to project P dominates the loss from lower effort. Hence, the quality of project P must be high enough to make an agent willing to disclose. From condition (16), we get two thresholds for P, which depend on the sharing rule $\boldsymbol{\alpha}$. If the quality of P is high enough,

$$P \geq P_i^d(\boldsymbol{\alpha}) \equiv \left[\frac{q(\alpha_i\gamma_i^2 q + 2\alpha_j\gamma_j^2)}{\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2}\right]^{1/2}, \tag{17}$$

agent i is willing to disclose his information. If the quality of P is low,

$$P \leq P_i^c(\boldsymbol{\alpha}) \equiv \left[\frac{3\alpha_i\gamma_i^2 q^2 + 2\alpha_j\gamma_j^2 q(2+q)}{3(\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2)}\right]^{1/2}, \tag{18}$$

agent i would conceal any information he gets. The disclosure decisions, and hence the thresholds, are independent of the disclosure strategy of the other agent since an informed agent knows that the other agent did not receive information. For an agent i the thresholds are thus unique. Furthermore, $P_i^c < P_i^d$ because the expectation of the uninformed agent $\hat{E}_j[Q]$ increases in the probability of disclosing d_i and thus incentives to disclose decrease in d_i. Therefore, full disclosure $d_i = 1$ with $\hat{E}_j[Q] = 1$, requires a higher P to induce disclosure than full concealment $d_i = 0$ with $\hat{E}_j[Q] = \frac{2+q}{3}$. The following graph shows the thresholds and the optimal disclosure strategy of agent i on the P-line:

The two thresholds lie in the range $[q, E[Q]]$. If $P = q$, agents will always conceal since adaptation has no benefit and discourages the partner. If $P = E[Q]$, the benefit of adaptation is always high enough to induce full disclosure. Between his two thresholds, an agent is not willing to fully disclose or to fully conceal. If the agent fully discloses, the other agent has high motivation whenever he does not get any information, since he is then rather sure that the quality of project Q is high. This makes concealing more attractive for the informed agent. If the agent fully conceals, the effect on the other agent's motivation is weak. Full disclosure would then be better for the informed agent. Between the thresholds, an equilibrium thus only exists when the agent partially discloses with probability $\delta_i(\boldsymbol{\alpha}) \in (0,1)$ that makes him just indifferent between disclosing and concealing. Being indifferent, he is then also willing to disclose with this probability

$$\delta_i(\boldsymbol{\alpha}) = \frac{3\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2}{\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2} + \frac{4\alpha_j\gamma_j^2}{\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2}\frac{P^2 - q}{P^2 - q^2}. \tag{19}$$

Hence, agent i's unique optimal disclosure strategy given P is

$$d_i^* = \begin{cases} 1 & \text{if } P \geq P_i^d \\ \delta_i(\boldsymbol{\alpha}) & \text{if } P \in (P_i^c, P_i^d) \\ 0 & \text{if } P \leq P_i^c. \end{cases} \tag{20}$$

Since there is a unique optimal disclosure strategy for each agent (which is independent of the disclosure strategy of the other agent), there is always a unique equilibrium. An equilibrium in which both agents fully disclose arises whenever adaptation is important enough, i.e. if and only if P is high and lies above the disclosure thresholds of both agents $P \geq \max[P_L^d, P_H^d]$. Full concealment is the equilibrium when adaptation is not important, i.e. if and only if P lies below the concealment thresholds of both agents $P \leq \min[P_L^c, P_H^c]$. For intermediate values of P, asymmetric equilibria arise in which agents adapt different disclosure strategies.

Whether agents want to disclose or conceal depends on the share of revenue they receive. An increase in the own share (which implies a decrease in the other's share) has three effects on the disclosure strategy of an agent. First, he benefits more from a better adaptation to the state of the world. Second, the effect on the other agent's motivation is weaker, since the other agent reacts less to changes in expected quality. And finally, the agent benefits more from the difference in motivation of the other agent. While the first two effects are in favor of disclosure, the third effect is in favor of concealing. It turns out that the first and second effect always dominate and an agent is more likely to disclose if he gets a higher share.

Lemma 1.1. *The propensity of an agent to disclose private information increases in his own share of revenue and decreases in the other agent's share of revenue.*

The thresholds P_i^d and P_i^c decrease in the own share of revenue. If the own share increases, budget balance implies that the other's share decreases, which lowers P_i^d and P_i^c even more. The probability of disclosing $\delta_i(\boldsymbol{\alpha})$ in the range of P between the thresholds increases in the own share and decreases in the partner's share. The proofs can be found in the Appendix.

1.5.3 Full information sharing

Since the disclosure of information leads to the choice of the project with higher quality, one question we can ask is which sharing rule is optimal for information sharing in the sense that it maximizes the probability that agents fully share their information. The two agents fully disclose if P lies above their thresholds P_L^d and P_H^d. Hence, we want to find the sharing rule $\boldsymbol{\alpha}$ that minimizes the maximum of the thresholds. As stated in Lemma 1.1, any change in the sharing rule $\boldsymbol{\alpha}$ moves the thresholds in opposite directions. Therefore, the maximum is minimized when the thresholds are equalized, i.e. when $\boldsymbol{\alpha}$ is such that $P_L^d(\boldsymbol{\alpha}) = P_H^d(\boldsymbol{\alpha})$. This equation gives us the optimal shares for information sharing α_L^{dis} and $\alpha_H^{dis} = 1 - \alpha_L^{dis}$:

Proposition 1.3 (Full Information Sharing)**.** *If agents receive private information, the partnership's ability to share information is optimized (i.e. the range of parameters for which $d_L^* = d_H^* = 1$ is maximized) with the shares:*

$$\alpha_L^{dis} = \frac{\gamma_H^2}{\gamma_L^2 + \gamma_H^2} \quad \textit{and} \quad \alpha_H^{dis} = \frac{\gamma_L^2}{\gamma_L^2 + \gamma_H^2}. \tag{21}$$

The less productive agent receives a higher share $\alpha_L^{dis} > \frac{1}{2}$.

The intuition for this result is as follows. The incentives to conceal are higher if the other agent reacts strongly to changes in expected quality of the project. Given equal shares, the more productive agent would react more strongly than the less productive agent, since his effort has a higher effect on revenue. The less productive agent thus has a higher incentive to conceal when sharing equally. Increasing the share of the less productive agent (and thereby decreasing the share of the more productive agent) balances the effort reactions to changes in expected quality and thereby the incentives to disclose.

This result is in contrast to the result from our benchmark case, where the more productive agent should get a higher share and provide higher effort in order to maximize surplus. If we want to induce full information sharing, the less productive agent should get a higher share and will potentially even provide higher effort. Corollary 1.1 follows directly from Propositions 1.1 and 1.3.

Corollary 1.1. *The revenue allocation that optimizes information sharing is diametrically opposed to the revenue allocation that maximizes surplus in the absence of informational asymmetries, i.e.* $\alpha_L^{dis} = 1 - \alpha_L^{sym}$.

Since $\boldsymbol{\alpha}^{dis}$ equalizes the thresholds, both agents will fully disclose if $P \geq \underline{P} \equiv P_L^d(\boldsymbol{\alpha}^{dis}) = \left[\frac{1}{3}q(2+q)\right]^{1/2}$. If the quality of project P is high enough $P \geq \bar{P} \equiv P_L^d(\boldsymbol{\alpha}^{sym}) = \left[\frac{q(q\gamma_L^4+2\gamma_H^4)}{\gamma_L^4+2\gamma_H^4}\right]^{1/2}$, agents would disclose also with the shares $\boldsymbol{\alpha}^{sym}$. Figure 1.1 depicts total expected surplus (13) given optimal disclosure strategies as a function of P, once with $\boldsymbol{\alpha}^{dis}$ and once with $\boldsymbol{\alpha}^{sym}$.

In this example with $q = 0.1$, $\gamma_L = 0.8$ and $\gamma_H = 1$, we find that for values of P close to $\bar{P}$, $\boldsymbol{\alpha}^{sym}$ is preferred to $\boldsymbol{\alpha}^{dis}$. However, given $\boldsymbol{\alpha}^{sym}$, agent L starts to conceal when P decreases, which leads to a loss in surplus. We find a range of P in which inducing full disclosure with $\boldsymbol{\alpha}^{dis}$ is preferred to $\boldsymbol{\alpha}^{sym}$.

This observation, Corollary 1.1 and the fact that $\alpha_L^{equal} = \frac{1}{2} = \frac{\alpha_L^{sym}+\alpha_L^{dis}}{2} \in (\alpha_L^{sym}, \alpha_L^{dis})$, suggest that equal sharing could optimally balance the incentives between information sharing and effort provision.

1.5.4 Inducing full disclosure

Instead of choosing optimal disclosure shares $\boldsymbol{\alpha}^{dis}$, a smaller distortion of the sharing rule $\boldsymbol{\alpha}^{sym}$ might be enough to keep agents disclosing when P falls

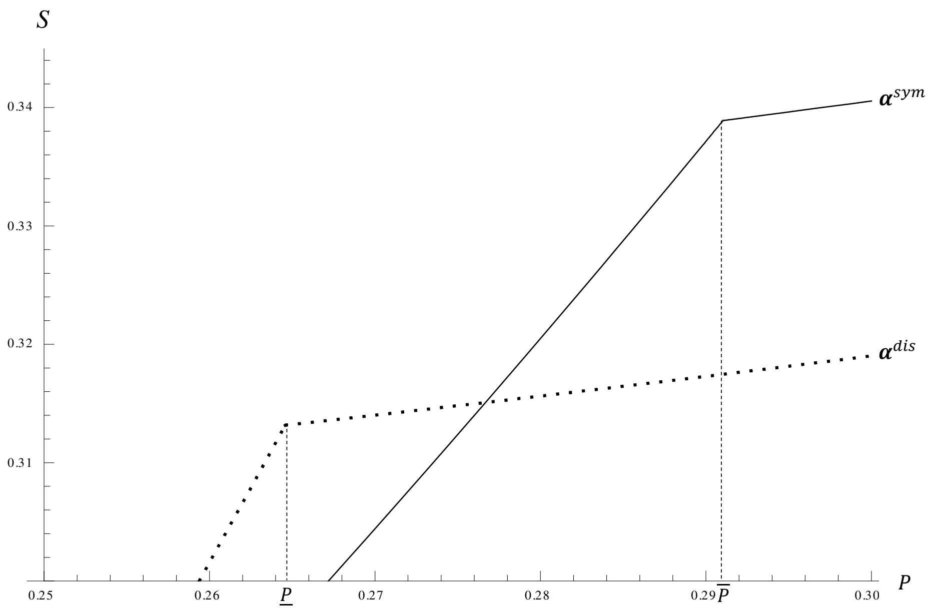

Figure 1.1: **Surplus with optimal symmetric and optimal disclosure shares.** Surplus as a function of the alternative project's quality P, given $\boldsymbol{\alpha}^{sym}$ (solid) and $\boldsymbol{\alpha}^{dis}$ (dotted) when $q = 0.1$, $\gamma_L = 0.8$ and $\gamma_H = 1$.

below $\bar{P}$. In other words, when full disclosure is possible, i.e. $P \geq \underline{P}$, we can maximize surplus subject to the constraint that both agents are willing to disclose. Since incentives to disclose increase in the agent's own share and decrease in the other's share, agent L is willing to disclose if his share is high enough:

$$\alpha_L \geq \underline{\alpha} \equiv \frac{2\gamma_H^2(P^2 - q)}{2\gamma_H^2(P^2 - q) - \gamma_L^2(P^2 - q^2)}. \tag{22}$$

For values of P below the threshold $\bar{P}$, agent L needs a higher share than α_L^{sym} in order to be willing to disclose. Therefore, we know that $\underline{\alpha} > \alpha_L^{sym}$ if $P \in [\underline{P}, \bar{P})$. Agent H is willing to disclose if the share of agent L is not too high:

$$\alpha_L \leq \bar{\alpha} \equiv \frac{\gamma_H^2(P^2 - q^2)}{\gamma_H^2(P^2 - q^2) - 2\gamma_L^2(P^2 - q)}. \tag{23}$$

Inducing full disclosure requires choosing a sharing rule for which $\underline{\alpha} \leq \alpha_L \leq \bar{\alpha}$. This is possible if $\underline{\alpha} \leq \bar{\alpha}$ which is true for all $P \geq \underline{P}$.

As shown in Section 1.5.1, surplus given full disclosure is strictly concave in α_L and maximized at α_L^{sym}. In order to maximize surplus under the constraint of full disclosure, we thus need to get as close as possible to α_L^{sym}. Taking into account that $\alpha_L^{sym} < \underline{\alpha} \leq \bar{\alpha}$ if $P \in [\underline{P}, \bar{P})$ and $\alpha_L^{sym} \in [\underline{\alpha}, \bar{\alpha}]$ if $P \geq \bar{P}$, we find the optimal constraint sharing rule $\boldsymbol{\alpha}^f = (\alpha_L^f, \alpha_H^f)$:

Proposition 1.4 (Optimal sharing rule under the constraint of full disclosure)**.** *If it is possible to induce full disclosure with $\boldsymbol{\alpha}^{sym}$, i.e. $P \geq \bar{P}$, the optimal shares of revenue under the restriction that we induce full disclosure are*

$$\alpha_L^f = \alpha_L^{sym} \quad \textit{and} \quad \alpha_H^f = \alpha_H^{sym}. \tag{24}$$

If it is not possible to induce full disclosure with $\boldsymbol{\alpha}^{sym}$ but full disclosure is feasible, i.e. $P \in [\underline{P}, \bar{P})$, the optimal constraint shares are

$$\alpha_L^f = \underline{\alpha} \quad \textit{and} \quad \alpha_H^f = 1 - \underline{\alpha}. \tag{25}$$

The less productive agent gets a higher share, i.e. $\alpha_L^f > \frac{1}{2}$, if $P \in [\underline{P}, P^e)$ with $P^e \equiv \left[\frac{q(q\gamma_L^2 + 2\gamma_H^2)}{\gamma_L^2 + 2\gamma_H^2}\right]^{1/2}$.

In contrast to $\boldsymbol{\alpha}^{sym}$ and $\boldsymbol{\alpha}^{dis}$, the optimal constraint distribution of revenue depends on P. When P falls below $\bar{P}$, the share for the less productive agent has to increase compared to α_L^{sym} in order to keep him disclosing. For decreasing P, his share increases from α_L^{sym} at $\bar{P}$ until it reaches α_L^{dis} at $\underline{P}$. Equal sharing is constraint optimal at P^e, which is defined by $\alpha_L^f(P^e) = \frac{1}{2}$ and always lies in $[\underline{P}, \bar{P})$. Hence, the less productive agent receives a higher share than the more productive agent whenever $P \in [\underline{P}, P^e)$.

Figure 1.2 depicts the total expected surplus (13) given optimal disclosure strategies and given $\boldsymbol{\alpha}^f(P)$, $\boldsymbol{\alpha}^{sym}$ and $\boldsymbol{\alpha}^{dis}$. Whenever it is possible to induce full disclosure, i.e. $P \geq \underline{P}$, the sharing rule $\boldsymbol{\alpha}^f(P)$ is preferred to $\boldsymbol{\alpha}^{dis}$, since both induce full disclosure but $\boldsymbol{\alpha}^f(P)$ is closer to the optimal sharing rule given full disclosure $\boldsymbol{\alpha}^{sym}$. In our example, $\boldsymbol{\alpha}^f(P)$ is also weakly preferred to $\boldsymbol{\alpha}^{sym}$. However, this is not necessarily general, since it might be surplus increasing to allow for some concealment. This is true if the loss of motivation dominates the gain due to better adaptation.

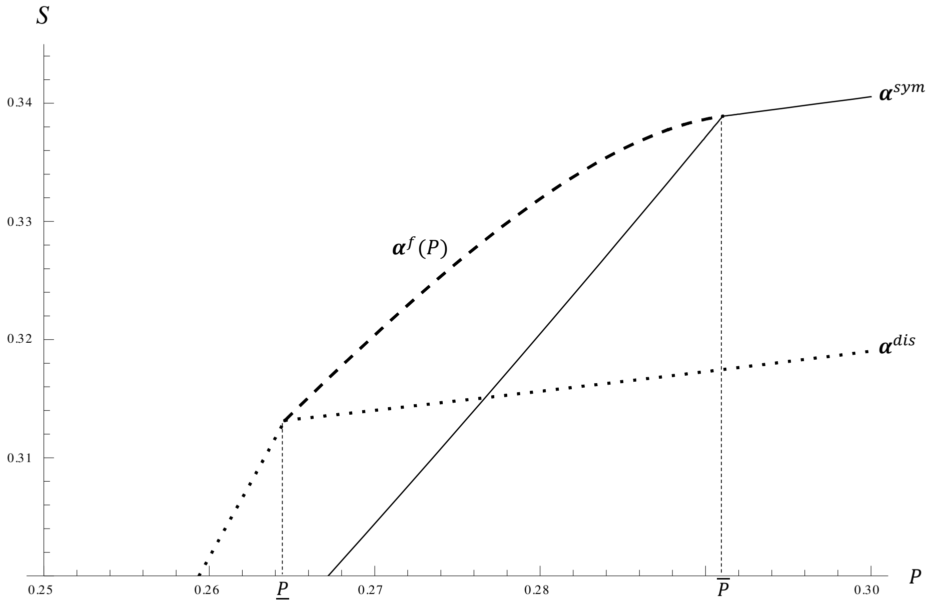

Figure 1.2: **Surplus under the constraint of full disclosure.** Surplus as a function of the alternative project's quality P, given $\boldsymbol{\alpha}^{sym}$ (solid), $\boldsymbol{\alpha}^{dis}$ (dotted) and $\boldsymbol{\alpha}^{f}(P)$ (dashed) when $q = 0.1$, $\gamma_L = 0.8$ and $\gamma_H = 1$.

Before considering the overall optimal sharing rule in Section 1.6, we show that our assumption with respect to the project selection rule comes without loss of generality.

Project selection. Take any voting rule such that if an agent votes for project X, the probability that this project is chosen increases. Furthermore, if agents both vote for the same project, that project is chosen. This implies that both agents would always vote for the project from which they expect a higher utility.

If one of the agents was informed and discloses this information, both agents vote in favor of project P. This is implied by Assumption 1 and the fact that once evidence is disclosed, project Q is known to have low quality for sure. If an agent does not receive any evidence, it is not immediately clear which project he would vote for. On the one hand, no evidence strengthens the belief that project Q is of good quality. On the other hand, given the quality is low, the other agent is expected to have evidence and to provide low effort. An uninformed agent i expects that if project Q is chosen, he gets utility

$$U_i^Q = \frac{1-d_j}{3-d_j}\alpha_i[\gamma_i e_i^*(\hat{E}_i[Q]) + \gamma_j e_j^*(q)]q + \frac{2}{3-d_j}\alpha_i[\gamma_i e_i^*(\hat{E}_i[Q]) + \gamma_j e_j^*(\hat{E}_j[Q])] - \frac{1}{2}e_i^*(\hat{E}_i[Q])^2 \tag{26}$$

with $\hat{E}_i[Q] = \frac{(1-d_j)q+2}{3-d_j}$ and $\hat{E}_j[Q] = \frac{(1-d_i)q+2}{3-d_i}$. Given individually optimal effort choices and our assumption that $P < E[Q]$, we show in the Appendix that surplus from project P is strictly lower in this situation. Hence, the uninformed agent would vote for project Q. An informed agent who did not disclose will also vote for project Q. Otherwise, he would have made sure that project P is chosen by disclosing his evidence in the first place. Consequently, agents will agree on the status quo project Q whenever no evidence was disclosed.

1.6 Optimal allocation of revenue

In this section, we first determine the sharing rule $\boldsymbol{\alpha}^*$ that maximizes total expected surplus, taking into account that disclosure strategies are chosen by the agents. Then, we discuss the optimality of equal sharing.

1.6.1 Optimal sharing rule

Total expected surplus of the two agents takes into account the same cases as in (13) but now considers the optimal disclosure strategies of the agents:

$$\begin{aligned} E[S] = {} & \frac{1}{4}[d_L^* S_P(e_L^*(P), e_H^*(P)) + (1-d_L^*)S_q(e_L^*(q), e_H^*(\hat{E}_H[Q]))] \\ & + \frac{1}{4}[d_H^* S_P(e_L^*(P), e_H^*(P)) + (1-d_H^*)S_q(e_L^*(\hat{E}_L[Q]), e_H^*(q))] \\ & + \frac{1}{2}S_1(e_L^*(\hat{E}_L[Q]), e_H^*(\hat{E}_H[Q])). \end{aligned} \tag{27}$$

Figure 1.3 shows the thresholds P for full disclosure and full concealment of the two agents as a function of α_L. As long as $P \geq \underline{P}$, adaptation is important enough such that at least one of the agents will fully disclose and

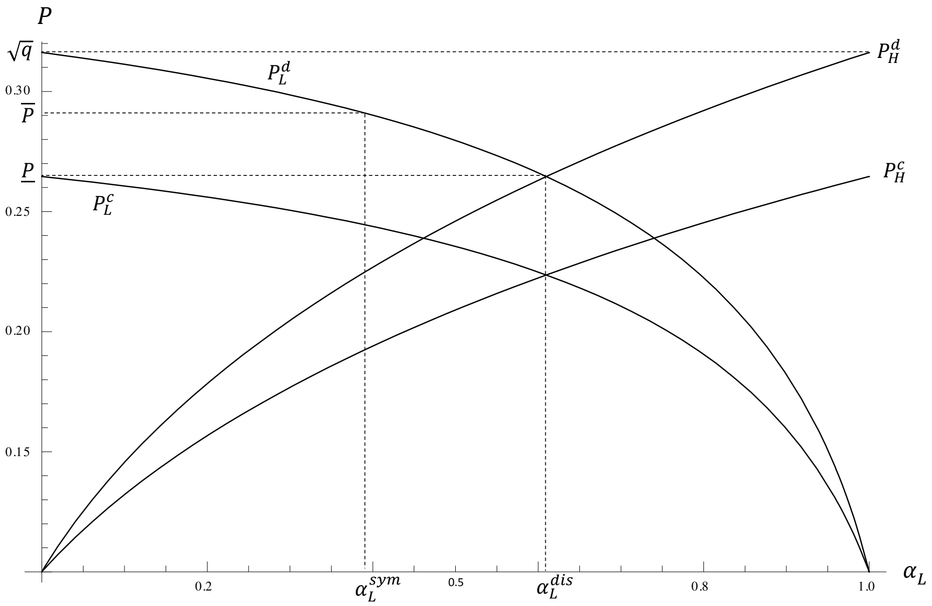

Figure 1.3: **Disclosure and concealment thresholds.** Thresholds P_i^d and P_i^c for agents $i = L, H$ as a function of the less productive agent's share α_L given $q = 0.1$, $\gamma_L = 0.8$ and $\gamma_H = 1$.

none of the agents would ever fully conceal. For $P \geq \sqrt{q}$, both agents fully disclose independent of the revenue sharing rule $\boldsymbol{\alpha}$.

Lemma 1.2. *Suppose* $P \in [\underline{P}, E[Q])$. *For any* $\alpha_L \in [0, 1]$, *at least one agent fully discloses and none of the agents fully conceals.*

You find the proof in the Appendix. Lemma 1.2 implies that in the range of P in which full disclosure is possible to induce, we can restrict attention to three types of equilibria: both agents fully disclose, agent L partially discloses while agent H fully discloses and agent H partially discloses while agent L fully discloses.

In the following, we normalize $\gamma_L = \gamma < 1$ and $\gamma_H = 1$. Proposition 1.5 characterizes the surplus-maximizing sharing rule $\boldsymbol{\alpha}^* = (\alpha_L^*, 1 - \alpha_L^*)$ when inducing full disclosure is possible. A question of particular interest is whether the optimal sharing rule $\boldsymbol{\alpha}^*$ induces full adaptation, i.e. the certain adoption of the project with the higher (expected) quality.

Proposition 1.5. *Suppose that $P \in [\underline{P}, E[Q])$. The revenue allocation that maximizes total expected surplus can be characterized as follows:*

- *If $P \in [\bar{P}, E[Q])$ then $\alpha_L^* = \alpha_L^{sym}$ is optimal. The project with the higher (expected) quality is always adopted, i.e. $d_L^* = d_H^* = 1$.*
- *If $P \in [\hat{P}, \bar{P})$ then $\alpha_L^* = \alpha_L^f$ is optimal. The project with the higher (expected) quality is always adopted, i.e. $d_L^* = d_H^* = 1$.*
- *If $P \in [\underline{P}, \hat{P})$ then $\alpha_L^* \in (\alpha_L^{sym}, \alpha_L^f)$ is optimal. The project with the higher (expected) quality fails to be adopted with positive probability, i.e. $d_L^* < d_H^* = 1$.*

If $\gamma > \underline{\gamma}(q) \equiv \sqrt{\frac{2(2+3q+q^2)}{7+4q+q^2}}$, then $\hat{P} = \underline{P}$, i.e. inducing full adaptation is optimal whenever feasible.

If $P \geq \sqrt{q}$, agents fully disclose independent of the sharing rule. It is thus straightforward that $\boldsymbol{\alpha}^{sym}$ is optimal. For $P < \sqrt{q}$, we have to consider that different sharing rules imply different disclosure strategies. Agents fully disclose if $\alpha_L \in [\underline{\alpha}, \bar{\alpha}]$. We argued in Section 1.5.4 that within this range of α_L, $\underline{\alpha}$ would be the optimal choice for total surplus if $P \in [\underline{P}, \bar{P})$ and α_L^{sym} is optimal if $P \geq \bar{P}$. However, it might be surplus increasing to choose a sharing rule that does not lie in this range, i.e. such that one of the agents starts concealing, since this could mitigate the free-riding problem of the team. If $\alpha_L > \bar{\alpha}$, agent H starts concealing partially. The surplus is then decreasing in α_L for all $P \in [\underline{P}, \sqrt{q})$. Hence, the highest surplus we can get in $[\bar{\alpha}, 1]$ is at $\bar{\alpha}$. This brings us back to full disclosure. If $\alpha_L < \underline{\alpha}$, agent L starts concealing partially. We can show that the surplus when agent L is disclosing and agent H partially conceals is concave in α_L. Furthermore, it is strictly increasing at $\underline{\alpha}$ for $P \in [\hat{P}, \sqrt{q})$, with $\hat{P} \in [\underline{P}, \bar{P})$. Hence, for such P, all $\alpha_L < \underline{\alpha}$ would yield lower surplus than $\underline{\alpha}$. $\underline{\alpha}$ maximizes surplus and again brings us back to full disclosure. For $P \in [\underline{P}, \hat{P})$, allowing for some concealment increases the surplus. The proofs can be found in the Appendix.

Figure 1.4 emphasizes the consequences of optimal sharing for adaptation.

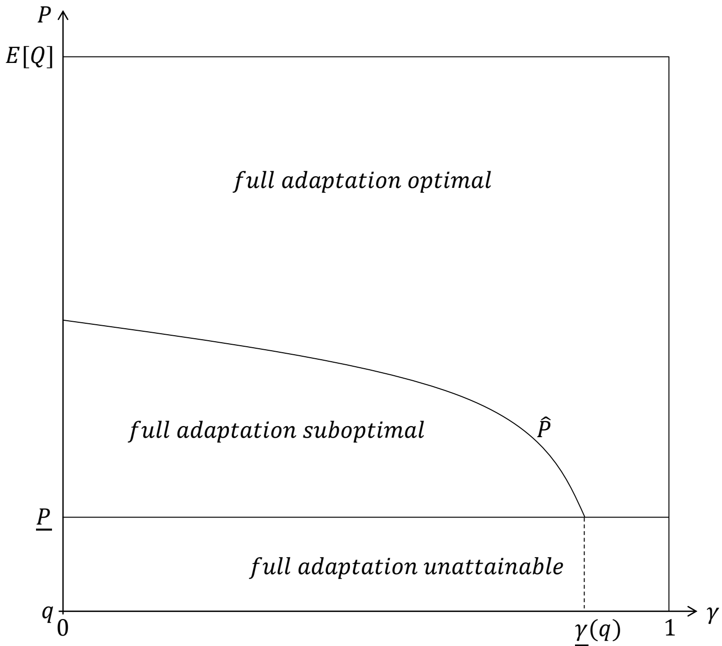

Figure 1.4: **Adaptation.** Characterization of the degree of adaptation under the surplus-maximizing sharing rule $\boldsymbol{\alpha}^*$ in dependence of the partners' heterogeneity and the alternative project's quality P for given q.

Whether full adaptation is optimal whenever feasible, i.e. for the whole range $[\underline{P}, E[Q])$, depends on the heterogeneity of agents γ and on the low quality of project Q. If agents are rather heterogeneous, i.e. $\gamma < \underline{\gamma}(q)$, it is not optimal to always adopt the project with the higher (expected) quality. The cost of inducing full adaptation is suboptimal motivation and this cost is higher if agents are heterogeneous. The threshold $\underline{\gamma}(q)$ is increasing in q. Hence, a higher low quality of project Q implies that full adaptation is less likely to be optimal. This is intuitive since a higher low quality of project Q makes disclosure and adaptation less important for surplus. Moreover, the size of the range in which full adaptation is feasible is decreasing in q and thus smaller for high q's.

1.6.2 On the optimality of equal sharing

Compared to the optimal shares given symmetric information $\boldsymbol{\alpha}^{sym}$ with $\alpha_L^{sym} < \frac{1}{2}$, equal shares have the advantage that the less productive agent is rather willing to disclose: From Lemma 1.1 we know that an increase in the own share increases the incentives to disclose. On the other hand, equal shares have the disadvantage that they do not optimally motivate given full disclosure. The benefit from improved information sharing potentially outweighs the loss from sub-optimal motivation. In our example with $q = 0.1$ and $\gamma = 0.8$, equal shares are indeed preferred to $\boldsymbol{\alpha}^{sym}$ for a range of values of P, as we see in Figure 1.5.

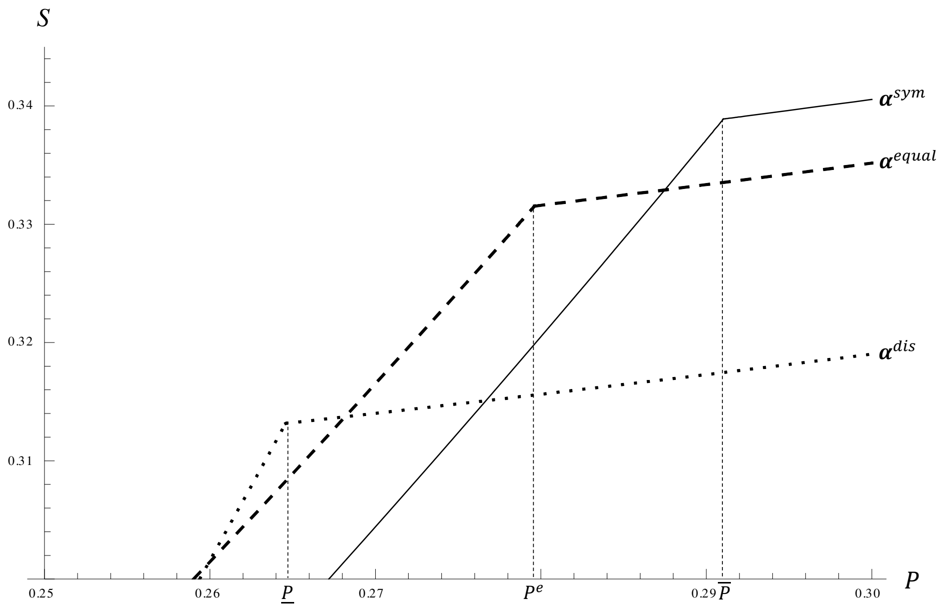

Figure 1.5: **Surplus with equal sharing rule.** Surplus as a function of the alternative project's quality P, given $\boldsymbol{\alpha}^{sym}$ (solid), $\boldsymbol{\alpha}^{dis}$ (dotted) and $\boldsymbol{\alpha}^{equal}$ (dashed) when $q = 0.1$ and $\gamma = 0.8$.

Given the distribution $\boldsymbol{\alpha}^{sym}$, both agents fully disclose for $P \geq 0.291$ while they disclose for $P \geq 0.28$ with equal sharing. With partial concealment of the less productive agent, surplus decreases faster if P decreases, and in our example, this implies equal sharing is preferred to $\boldsymbol{\alpha}^{sym}$ for the range $P \in [0.240, 0.287]$.

Instead of comparing equal shares with $\boldsymbol{\alpha}^{sym}$, we can directly consider the optimality of equal shares. There always exists a $P^e \in [\underline{P}, \bar{P})$ for which $\alpha_L^*(P^e) = \frac{1}{2}$. Hence, $\alpha_L^* = \frac{1}{2}$ is indeed optimal in some situations.

Proposition 1.6 (Optimal equal sharing)**.** *If $\gamma > \tilde{\gamma} \equiv (\sqrt{6} - 2)^{1/2}$ and $q < \tilde{q} \equiv \frac{(4-\gamma^{12}-4\gamma^{10}+9\gamma^8+24\gamma^6+4\gamma^4)^{1/2}}{\gamma^2(2+2\gamma^2-\gamma^4)} - \frac{1}{\gamma^2} \in (0,1)$, there exists a range $P \in [\hat{P}, P^e)$ in which giving a higher than equal share to the less productive agent $\alpha_L^* > \frac{1}{2}$ is optimal and equal shares $\alpha_L^* = \frac{1}{2}$ are optimal for $P^e \in [\underline{P}, \bar{P})$.*

You find the proof in the Appendix. In other words, Proposition 1.6 states that for some range of P it is optimal to give a higher share to the less productive agent if agents are rather homogeneous and the low quality of project Q is rather low. If agents are homogeneous, the loss of motivation is less severe than the loss due to worse adaptation when agents start to conceal. Furthermore, it is more likely to benefit from equal sharing if the low quality of project Q is low since the gain of better adaptation is high. In such a situation, inducing full disclosure and thereby adaptation is important and not the costs of sub-optimal motivation are not too high. Optimality then requires increasing the share of the less productive agent.

Consider the percentage loss of equal sharing relative to optimal sharing in this team situation with asymmetric information. In the symmetric information benchmark, we found that the percentage loss only depends on effort productivities and can go up to 25%. In the asymmetric information case with project selection, the percentage loss is a function of effort productivity γ, the low quality of project Q and the quality of project P. In our range of interest $P \in [\underline{P}, E[Q])$, we can calculate the loss whenever we can determine the optimal $\boldsymbol{\alpha}^*$:

$$\Delta E[S] = \frac{E[S(\boldsymbol{\alpha}^*)] - E[S(\boldsymbol{\alpha}^{equal})]}{E[S(\boldsymbol{\alpha}^*)]}. \tag{28}$$

For $q < \bar{q}$ and $\gamma > \underline{\gamma}$, we can determine $\boldsymbol{\alpha}^*$ for the full range $P \in [\underline{P}, E[Q])$. In such a situation, Figure 1.6 depicts the percentage loss from equal sharing in the symmetric information benchmark $\Delta E^{sym}[S]$ and in the asymmetric information case $\Delta E[S]$ as a function of quality P.

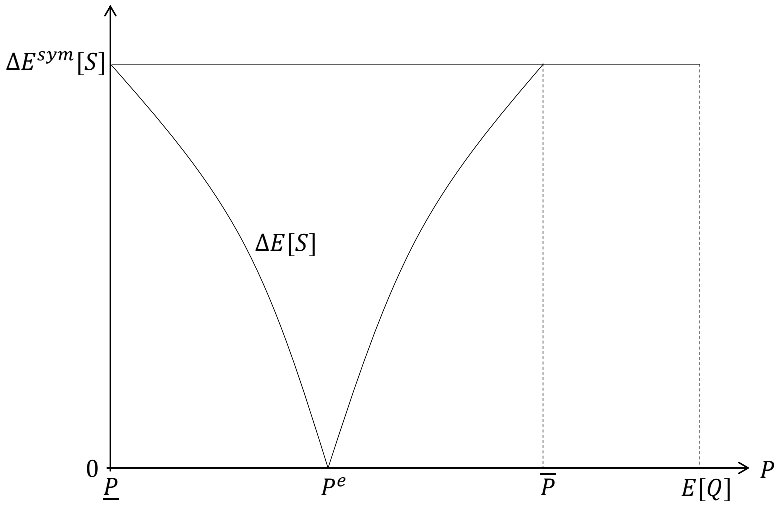

Figure 1.6: **Percentage loss in surplus from equal revenue sharing.** $\Delta E^{sym}[S]$ and $\Delta E[S]$ in dependence of the alternative project's quality P for given $\gamma > \underline{\gamma}$ and $q < \bar{q}$.

The percentage loss in surplus in the benchmark case is independent of P. The percentage loss in surplus given asymmetric information and project selection is lower for $P \in (\underline{P}, \bar{P})$, i.e. in the range of P in which full information sharing cannot be induced with $\boldsymbol{\alpha}^{sym}$ but would actually be surplus-maximizing. The loss is zero at P^e since equal sharing is then optimal.

Consider a team that only deviates from equal sharing if the gain is large enough. Such a decision rule would take into account that there are typically bureaucratic cost and rent-seeking when deviating from equal shares. Given asymmetric information and project selection, there is a larger set of parameters for which a team would stick to the default of equal sharing than in the symmetric information benchmark. In that sense, our model provides a rationale for more equal revenue sharing.

1.7 Robustness

In this section, we relax some assumptions of our model and show that Propositions 1.1 and 1.3 remain unchanged. Hence, our result that optimal incentives given symmetric information and optimal incentives for information sharing are diametrically opposed is robust regarding these assumptions. More specifically, we allow agents to differ in their ability to acquire information (1.7.1), we consider unverifiable evidence (1.7.2) and the possibility of "good news" (1.7.3). Finally, we let project success depend non-linearly on efforts which introduces inter-dependency of efforts (1.7.4).

1.7.1 Information acquisition

So far, we assumed that both agents are equally likely to receive information. In this section, we consider the case when agents differ in their ability to acquire information, i.e. in the likelihood of receiving information. Given the quality of project Q is low, agent L receives evidence with probability $\pi_L \in (0,1)$ while agent H gets evidence with $\pi_H \in (0,1)$. We assume that these probabilities are independent, i.e. it is possible that both, one or none of the agents is informed about the low quality of the status quo project. When an informed agent i decides whether to disclose, he knows that with some probability π_j, the other agent j is informed too and will then disclose his information with d_j. With some probability $(1-d_j)$, the other agent will not disclose given he is informed. Finally, with probability $(1-\pi_j)$, the other agent is not informed and updates his beliefs. We assume again that project P is selected if and only if evidence was disclosed.

If an agent j remains uninformed, his updated beliefs reflect the fact that being uninformed could mean that quality is high or that quality is low and the other agent was not informed either or that he was informed but conceals. These beliefs thus depend on the probabilities of being informed, π_i and π_j, of both agents:

$$\hat{E}_j[Q] = \frac{(1-d_i\pi_i)(1-\pi_j)q+1}{(1-d_i\pi_i)(1-\pi_j)+1}. \tag{29}$$

Since the incentives to disclose depend on the uninformed agent's beliefs, the threshold for disclosure now also depends on the probabilities of receiving information. The informed agent i discloses if and only if $P \geq P_i^d$, with

$$P_i^d = \left[\frac{q\{q\alpha_i\gamma_i^2[2-\pi_i-\pi_j(1-\pi_i)] + 2\alpha_j\gamma_j^2[1+(1-\pi_j)(1-\pi_i)q]\}}{(\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2)[2-\pi_i-\pi_j(1-\pi_i)]} \right]^{1/2}. \tag{30}$$

As in the case of symmetric ability of information acquisition, this threshold decreases in the own share α_i and increases in the other's share α_j. We show that in the Appendix. Therefore, we again maximize the range of P in which both agents disclose by minimizing the maximum of these two thresholds. The range is maximized when the thresholds are just equal which is true at $\alpha_L^{dis} = \frac{\gamma_H^2}{\gamma_L^2+\gamma_H^2}$. Hence, our result that the less productive agent needs a higher share to disclose information holds. The benchmark case does not change, i.e. $\boldsymbol{\alpha}^{sym}$ would be optimal with symmetric information. Information sharing and project selection provide a reason for more balanced sharing also in this setting. Since the overall optimal shares have to balance the incentives to provide effort and to disclose information, they are tilted towards more equality even if one agent is more productive *and* better at information acquisition.

1.7.2 Unverifiability

In this section, we consider the possibility that agents receive unverifiable and imperfect information about the status quo's quality. In comparison to our model with hard evidence, two novelties arise. First, agents are able to misrepresent their information and truth-telling becomes the issue. Second, agents are more motivated to exert effort on a given project when their "opinions" agree rather than disagree.

More specifically, we modify our model as follows. In Stage 1 each agent i receives a private, unverifiable, imperfect signal $s_i \in \{q, 1\}$ about the status quo's quality. Signals are independent and each signal has the same probability $\sigma \in (\frac{1}{2}, 1)$ of being correct. In Stage 2 agents communicate by sending a message $m_i \in \{q, 1\}$. As signals are unverifiable, agents may misrepresent their information by choosing $m_i \neq s_i$. In Stage 3 the status quo project is maintained unless both agents report low quality by issuing $m_L = m_H = q$.[7]

In the following, we derive the conditions that have to be satisfied for truth-telling $m_i = s_i$ to constitute an equilibrium. In a truth-telling equilibrium, the status quo's (updated) expected quality is given by

$$\hat{E}_i[Q] = \begin{cases} \frac{\sigma^2+(1-\sigma)^2 q}{\sigma^2+(1-\sigma)^2} \equiv \bar{Q} & \text{if} \quad s_L = s_H = 1 \\ \frac{1+q}{2} = E[Q] & \text{if} \quad s_L \neq s_H \\ \frac{\sigma^2 q+(1-\sigma)^2}{\sigma^2+(1-\sigma)^2} \equiv \underline{Q} & \text{if} \quad s_L = s_H = q \end{cases} \tag{31}$$

and agent i with revenue-share α_i and productivity γ_i who expects project X's quality to be $\hat{E}_i[X]$ exerts effort $e_i^*(\hat{E}_i[X]) = \alpha_i \gamma_i \hat{E}_i[X]$. Not surprisingly, agents have no incentive to lie when they observe "good news", $s_i = 1$, but might be tempted to misrepresent "bad news" by issuing $m_i = 1$ upon observation of $s_i = q$. Agent i's payoff from truth-telling $m_i = s_i = q$ is given by

$$\begin{aligned} U_i^t = {} & [\sigma^2 + (1-\sigma)^2] \left\{ \alpha_i[\gamma_i e_i^*(P) + \gamma_j e_j^*(P)]P - \frac{1}{2} e_i^*(P)^2 \right\} \\ & + 2\sigma(1-\sigma) \left\{ \alpha_i[\gamma_i e_i^*(E[Q]) + \gamma_j e_j^*(E[Q])]E[Q] - \frac{1}{2} e_i^*(E[Q])^2 \right\} \end{aligned} \tag{32}$$

whereas lying by issuing $m_i = 1$ when $s_i = q$ gives

$$\begin{aligned} U_i^l = {} & [\sigma^2 + (1-\sigma)^2] \left\{ \alpha_i[\gamma_i e_i^*(\underline{Q}) + \gamma_j e_j^*(E[Q])]\underline{Q} - \frac{1}{2} e_i^*(\underline{Q})^2 \right\} \\ & + 2\sigma(1-\sigma) \left\{ \alpha_i[\gamma_i e_i^*(E[Q]) + \gamma_j e_j^*(\bar{Q})]E[Q] - \frac{1}{2} e_i^*(E[Q])^2 \right\}. \end{aligned} \tag{33}$$

Truth-telling is optimal for agent i if and only if $U_i^t \geq U_i^l$ or equivalently $P > P_i^d$ with

$$P_i^d = \left[\frac{\frac{1}{2}\alpha_i^2 \gamma_i^2 \underline{Q}^2 + \alpha_i \alpha_j \gamma_j^2 \underline{Q} E[Q] + \frac{2\sigma(1-\sigma)}{\sigma^2+(1-\sigma)^2} \alpha_i \alpha_j \gamma_j^2 (\bar{Q} - E[Q]) E[Q]}{\frac{1}{2}\alpha_i^2 \gamma_i^2 + \alpha_i \alpha_j \gamma_j^2} \right]^{1/2}. \tag{34}$$

[7] We modify Assumption 1 by requiring $P > \underline{Q}$ rather than $P > q$ with $\underline{Q}$ as defined in (31). This ensures that, as in the model with evidence, the specified project selection rule can be rationalized as the outcome of an arbitrary voting procedure.

Truth-telling, $(m_L, m_H) = (s_L, s_H)$, forms an equilibrium if and only if $P \geq \max\{P_L^d, P_H^d\}$. Perhaps surprisingly, the range of parameters for which truth-telling constitutes an equilibrium is again maximized when $\alpha_L = \frac{\gamma_H^2}{\gamma_L^2+\gamma_H^2} = \alpha_L^{dis}$.

Our analysis in this section shows that Proposition 1.1 and the corresponding Corollary 1.1 remain valid in settings with non-verifiable information. In the model with signals, the economic mechanisms involved are similar to the ones in the model with evidence. However, there exists one additional mechanism. This mechanism is similar to a subordinate's propensity to conform with the views of his superior (Prendergast, 1993). Each agent has an incentive to issue a message that reinforces rather than contradicts his partner's signal. Since messages are issued simultaneously and signals are more likely to coincide than to contradict each other, agents therefore have an additional incentive to tell the truth. It is reassuring that our results remain unchanged even in the presence of such a *propensity to agree*.

1.7.3 Good news

Assume that agents also get information if there is "good news", i.e. if the quality of project Q is high. This means that there is *always* one agent informed and one agent uninformed. Given an agent receives "good news", he would want to work on project Q and the other agent to provide high effort. Both can be attained by disclosure and thus the only sub-game perfect strategy is to disclose whenever there is "good news". If an agent gets "bad news" and conceals, the uninformed agent knows that quality of project Q is low. He will thus provide low effort and the informed agent prefers to disclose and adopt project P. Hence, if there is *always* one agent who gets information, there is always full disclosure.

Alternatively, assume that if there is "good news", each agent gets information with independent probability $\pi \in (0, 1)$. Again, if an agent gets "good news", he would always disclose since there is no trade-off between motivation and adaptation. If an agent remains uninformed, he knows for sure that there was no "good news". However, he is not sure whether there was "bad news" or "no news". With probability $\frac{1}{2}(1-\pi)^2$, the quality of project Q is high but there was no information. With probability $\frac{1}{4}(1-d_i)$, there was "bad news" but the other agent conceals. Hence, the uninformed agent expects the quality of project Q to be

$$\hat{E}_j[Q] = \frac{\frac{1}{4}(1-d_i)q + \frac{1}{2}(1-\pi)^2}{\frac{1}{4}(1-d_i) + \frac{1}{2}(1-\pi)^2}. \tag{35}$$

In a full disclosure equilibrium, i.e. when $d_L^* = d_H^* = 1$, uninformed agents are sure again that there was no "bad news". Hence, the disclosure thresholds of quality P are the same as in the case when only "bad news" is possible. $\alpha_L^{dis} > \frac{1}{2}$ maximizes the propensity of full disclosure, while $\alpha_L^{sym} < \frac{1}{2}$ would maximize surplus given symmetric information.

1.7.4 Technology

Our model assumes a linear relation between individual efforts and the projects' likelihood of success. In the following, we relax this assumption by requiring that, instead of (1),

$$R_X(e_L, e_H) = r(\Sigma)X \qquad \text{with} \qquad \Sigma = \gamma e_L + e_H. \tag{36}$$

The function r is assumed to be increasing and concave and to take values in $[0,1]$. Agents share the revenue according to the sharing rule $\alpha_L = \alpha$ and $\alpha_H = 1-\alpha$. Note first that when the project's quality is (commonly) known to be X then equilibrium efforts, $e_L^*(X)$ and $e_H^*(X)$, are uniquely defined as the solution to the system of equations

$$e_L = \alpha\gamma r'(\Sigma)X \tag{37}$$

$$e_H = (1-\alpha)r'(\Sigma)X. \tag{38}$$

By the definition of Σ it must therefore hold that

$$\frac{\Sigma}{r'(\Sigma)} = (\alpha\gamma^2 + 1 - \alpha)X. \tag{39}$$

Define the solution to this equation as $\Sigma^*(\alpha)$ and note that $\Sigma^*(\alpha)$ is decreasing by the concavity of r.

Using $\Sigma^*(\alpha)$, we can write $e_L^* = \frac{\alpha\gamma}{\alpha\gamma^2+1-\alpha}\Sigma^*(\alpha)$ and $e_H^* = \frac{1-\alpha}{\alpha\gamma^2+1-\alpha}\Sigma^*(\alpha)$. In the symmetric information benchmark, the surplus-maximizing sharing rule is thus given by

$$\alpha^{sym} = \arg\max_{\alpha\in[0,1]} r(\Sigma^*(\alpha))X - \frac{1}{2}\frac{\alpha^2\gamma^2+(1-\alpha)^2}{(\alpha\gamma^2+1-\alpha)^2}\Sigma^*(\alpha)^2. \tag{40}$$

Using (39), the first order condition of this maximization problem can be written as

$$\left[1 - \frac{\alpha^2\gamma^2+(1-\alpha)^2}{\alpha\gamma^2+1-\alpha}\right] r'(\Sigma^*(\alpha))X\frac{\partial\Sigma^*(\alpha)}{\partial\alpha} + \frac{(1-2\alpha)\gamma^2}{(\alpha\gamma^2+1-\alpha)^3}\Sigma^*(\alpha)^2 = 0. \tag{41}$$

As the first term is negative, for the first order condition to hold, the second term must be positive. This shows that in the symmetric information benchmark, $\alpha^{sym} < \frac{1}{2}$, i.e. surplus is maximized by granting the more productive agent a larger share of revenue.

Next, consider the agents' disclosure incentives. Full disclosure is an equilibrium if and only if the following two inequalities are satisfied:

$$\begin{aligned} U_L^d = \alpha r(\gamma e_L^*(P) + e_H^*(P))P - \frac{1}{2}e_L^*(P)^2 \\ \geq \max_{e_L} \alpha r(\gamma e_L + e_H^*(1))q - \frac{1}{2}e_L^2 = U_L^c, \end{aligned} \tag{42}$$

$$\begin{aligned} U_H^d = (1-\alpha) r(\gamma e_L^*(P) + e_H^*(P))P - \frac{1}{2}e_H^*(P)^2 \\ \geq \max_{e_H} (1-\alpha) r(e_H + \gamma e_L^*(1))q - \frac{1}{2}e_H^2 = U_H^c. \end{aligned} \tag{43}$$

From (37) and (38) it follows that $e_L^*(X) = \frac{\gamma\alpha}{1-\alpha}e_H^*(X)$ and setting $\alpha = \alpha^{dis} = \frac{1}{1+\gamma^2}$ therefore implies that $U_H^d = \gamma^2 U_L^d$ and $U_H^c = \gamma^2 U_L^c$.[8] Hence, $U_L^d \geq U_L^c$ if and only if $U_H^d \geq U_H^c$ or, in other words, disclosure incentives are equalized, $P_L^d(\alpha) = P_H^d(\alpha)$, when $\alpha = \alpha^{dis}$. As before, the parameter space for which full disclosure constitutes an equilibrium is maximized when the less productive agent receives a larger share of revenue $\alpha = \alpha^{dis} > \frac{1}{2}$.

[8]To see that $U_H^c = \gamma^2 U_L^c$, transform the maximization variable e_H into $z = \frac{e_H}{\gamma}$ and use the fact that for $\alpha = \frac{\gamma^2}{1+\gamma^2}$, $\gamma e_L(1) = e_H(1)$.

While for technologies such as (36) a characterization of the partnership's surplus-maximizing sharing rule α^* proves elusive, our analysis in this section reveals that optimal incentives for motivation ($\alpha^{sym} < \frac{1}{2}$) and optimal incentives for adaptation ($\alpha^{dis} > \frac{1}{2}$) can be expected to be opposed quite generally.

1.8 Conclusion

This paper considers a standard situation of team production with effort substitutes, asymmetric information and project selection. When designing the optimal sharing rule, we find that there is a trade-off between motivation and information sharing. Optimal motivation given symmetric information requires giving a higher share to the more productive agent. Maximizing the propensity of information sharing requires the opposite distribution of revenue: to give a high share to the less productive agent. This result is robust to changes in the assumptions regarding the informational structure.

The trade-off gives a rationale for more equal sharing since there is a need to balance the incentives to provide effort and to share information.

Our main result characterizes the optimal shares when full disclosure is feasible. It turns out that if agents are rather heterogeneous and projects do not differ too much in quality in case of "bad news", some concealment is optimal. Furthermore, giving a higher or equal share to the less productive agent is optimal in a range of parameters, since the team benefits from improved information sharing.

A limitation of our results comes from the specific form of the revenue function. We do not consider complementary effort. However, complementarities would only bring more symmetry into the model and would therefore work in favor of equal sharing. Hence, we considered the most conservative case regarding equal sharing. Complementarities are left to future research.

In this paper, we took the organizational form (partnership) as given and determined the optimal shape (sharing rule). Our model could also be used to study the benefits of partnerships compared to other organizational forms.

1.9 Appendix

1.9.1 Proof of Proposition 1.1

Total expected surplus under symmetric information is

$$E^{sym}[S(\boldsymbol{\alpha})] = \frac{1}{2}S_1(e_L^*(1), e_H^*(1)) + \frac{1}{2}S_P(e_L^*(P), e_H^*(P)) \tag{44}$$

$$= \left[\gamma_L^2\alpha_L(1-\frac{\alpha_L}{2}) + \gamma_H^2\alpha_H(1-\frac{\alpha_H}{2})\right]\frac{1+P^2}{2}. \tag{45}$$

Take $\alpha_H = 1-\alpha_L$. We want to choose α_L in order to maximize the total expected surplus. The first order condition is

$$\frac{\partial E^{sym}[S(\boldsymbol{\alpha})]}{\partial \alpha_L} = \left[\gamma_L^2(1-\alpha_L) - \gamma_H^2\alpha_L\right]\frac{1+P^2}{2} \stackrel{!}{=} 0$$

$$\Leftrightarrow \alpha_L^{sym} = \frac{\gamma_L^2}{\gamma_L^2+\gamma_H^2} \tag{46}$$

The second order condition is

$$\frac{\partial^2 E^{sym}[S(\boldsymbol{\alpha})]}{\partial \alpha_L^2} = -(\gamma_L^2+\gamma_H^2)\frac{1+P^2}{2} < 0 \tag{47}$$

Strictly concave in α_L, hence we found the unique maximum.

1.9.2 Proof of Proposition 1.2

Total expected surplus given disclosure strategies is

$$\begin{aligned}
&E[S(\boldsymbol{\alpha}, d_L, d_H)] = \qquad (48)\\
&\frac{1}{4}(d_L+d_H)[(\alpha_L\gamma_L^2P + \alpha_H\gamma_H^2P)P - \frac{1}{2}\alpha_L^2\gamma_L^2P^2 - \frac{1}{2}\alpha_H^2\gamma_H^2P^2]\\
&+\frac{1}{4}(1-d_L)[(\alpha_L\gamma_L^2q + \alpha_H\gamma_H^2\hat{E}_H[Q])q - \frac{1}{2}\alpha_L^2\gamma_L^2q^2 - \frac{1}{2}\alpha_H^2\gamma_H^2\hat{E}_H[Q]^2]\\
&+\frac{1}{4}(1-d_H)[(\alpha_L\gamma_L^2\hat{E}_L[Q] + \alpha_H\gamma_H^2q)q - \frac{1}{2}\alpha_L^2\gamma_L^2\hat{E}_L[Q]^2 - \frac{1}{2}\alpha_H^2\gamma_H^2q^2]\\
&+\frac{1}{2}[(\alpha_L\gamma_L^2\hat{E}_L[Q] + \alpha_H\gamma_H^2\hat{E}_H[Q]) - \frac{1}{2}\alpha_L^2\gamma_L^2\hat{E}_L[Q]^2 - \frac{1}{2}\alpha_H^2\gamma_H^2\hat{E}_H[Q]^2]
\end{aligned}$$

We can simplify this expression by separating revenues and costs for each agent:

$$
\begin{aligned}
&E[S(\boldsymbol{\alpha}, d_L, d_H)] = \qquad (49)\\
&\quad \alpha_L \gamma_L^2 [\frac{1}{4}(d_L + d_H)P^2 + \frac{1}{4}(1-d_L)q^2 + \frac{1}{4}(1-d_H)q\hat{E}_L[Q] + \frac{1}{2}\hat{E}_L[Q]]\\
&\quad +\alpha_H \gamma_H^2 [\frac{1}{4}(d_L + d_H)P^2 + \frac{1}{4}(1-d_H)q^2 + \frac{1}{4}(1-d_L)q\hat{E}_H[Q] + \frac{1}{2}\hat{E}_H[Q]]\\
&\quad -\frac{1}{2}\alpha_L^2 \gamma_L^2 [\frac{1}{4}(d_L + d_H)P^2 + \frac{1}{4}(1-d_L)q^2 + \frac{1}{4}(1-d_H)\hat{E}_L[Q]^2 + \frac{1}{2}\hat{E}_L[Q]^2]\\
&\quad -\frac{1}{2}\alpha_H^2 \gamma_H^2 [\frac{1}{4}(d_L + d_H)P^2 + \frac{1}{4}(1-d_H)q^2 + \frac{1}{4}(1-d_L)\hat{E}_H[Q]^2 + \frac{1}{2}\hat{E}_H[Q]^2]
\end{aligned}
$$

Note that $\frac{1}{4}(1-d_i)q\hat{E}_j[Q] + \frac{1}{2}\hat{E}_j[Q] = \frac{1}{4}(1-d_i)\hat{E}_j[Q]^2 + \frac{1}{2}\hat{E}_j[Q]^2$ for $i = L, H$. Hence, the expected surplus can be written as

$$
E[S(\boldsymbol{\alpha}, d_L, d_H)] = \alpha_L \gamma_L^2 \hat{q}_L + \alpha_H \gamma_H^2 \hat{q}_H - \frac{1}{2}\alpha_L^2 \gamma_L^2 \hat{q}_L - \frac{1}{2}\alpha_H^2 \gamma_H^2 \hat{q}_H \qquad (50)
$$

with

$$
\hat{q}_i = \frac{1}{4}\left[(d_i + d_{-i})P^2 + (1-d_i)q^2 + (1-d_{-i})q\hat{E}_i[Q] + 2\hat{E}_i[Q]\right] \qquad (51)
$$

and

$$
\hat{E}_i[Q] = \frac{1-d_{-i}}{3-d_{-i}}q + \frac{2}{3-d_{-i}}, \quad i = L, H. \qquad (52)
$$

Take $\alpha_H = 1 - \alpha_L$. We want to choose α_L in order to maximize the total expected surplus. The optimal shares given disclosure strategies follow from the first order condition

$$
\frac{\partial E[S(\boldsymbol{\alpha}, d_L, d_H)]}{\partial \alpha_L} = \gamma_L^2 \hat{q}_L - \gamma_H^2 \hat{q}_H - \alpha_L \gamma_L^2 \hat{q}_L + (1-\alpha_L)\gamma_H^2 \hat{q}_H \stackrel{!}{=} 0 \qquad (53)
$$

$$
\Leftrightarrow \alpha_L^*(d_L, d_H) = \frac{\gamma_L^2 \hat{q}_L}{\gamma_L^2 \hat{q}_L + \gamma_H^2 \hat{q}_H}. \qquad (54)
$$

The second order condition is

$$
\frac{\partial^2 E[S(\boldsymbol{\alpha}, d_L, d_H)]}{\partial \alpha_L^2} = -\gamma_L^2 \hat{q}_L - \gamma_H^2 \hat{q}_H < 0. \qquad (55)
$$

Expected surplus given disclosure strategies is strictly concave in α_L, hence we found the unique maximum.

Note that $d_L = d_H$ implies that $\hat{q}_L = \hat{q}_H$. Hence, if both agents play the same disclosure strategy, we are back to the shares $\boldsymbol{\alpha}^{sym}$.

It is optimal to give a higher share to the less productive agent iff

$$\alpha_L^*(d_L, d_H) \geq \frac{1}{2} \Leftrightarrow \gamma_L^2 \geq \gamma_H^2 \frac{\hat{q}_H}{\hat{q}_L}. \tag{56}$$

1.9.3 Proof of Lemma 1.1

P_i^d is strictly decreasing in i's share α_i:

$$\frac{\partial P_i^d}{\partial \alpha_i} = -\frac{q(1-q)\gamma_i^2\gamma_j^2}{\left[(\alpha_i\gamma_i^2 q + 2\alpha_j\gamma_j^2)q(\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2)^3\right]^{1/2}} < 0. \tag{57}$$

P_i^d is strictly increasing in j's share α_j:

$$\frac{\partial P_i^d}{\partial \alpha_j} = \frac{q(1-q)\gamma_i^2\gamma_j^2}{\left[(\alpha_i\gamma_i^2 q + 2\alpha_j\gamma_j^2)q(\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2)^3\right]^{1/2}} > 0. \tag{58}$$

P_i^c is strictly decreasing in i's share α_i:

$$\frac{\partial P_i^c}{\partial \alpha_i} = -\frac{\frac{2}{3}q(1-q)\gamma_i^2\gamma_j^2\alpha_j}{\left\{[\alpha_i\gamma_i^2 q + \frac{2}{3}\alpha_j\gamma_j^2(2+q)]q(\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2)^3\right\}^{1/2}} < 0. \tag{59}$$

P_i^c is strictly increasing in j's share α_j:

$$\frac{\partial P_i^c}{\partial \alpha_j} = \frac{\frac{2}{3}q(1-q)\gamma_i^2\gamma_j^2\alpha_i}{\left\{[\alpha_i\gamma_i^2 q + \frac{2}{3}\alpha_j\gamma_j^2(2+q)]q(\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2)^3\right\}^{1/2}} > 0. \tag{60}$$

δ_i is strictly increasing in i's share α_i:

$$\frac{\partial \delta_i}{\partial \alpha_i} = \frac{4q(1-q)\gamma_i^2\gamma_j^2\alpha_j}{(P^2-q^2)(\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2)^2} > 0. \tag{61}$$

δ_i is strictly decreasing in j's share α_j:

$$\frac{\partial \delta_i}{\partial \alpha_j} = -\frac{4q(1-q)\gamma_i^2\gamma_j^2\alpha_j}{(P^2-q^2)(\alpha_i\gamma_i^2 + 2\alpha_j\gamma_j^2)^2} < 0. \tag{62}$$

1.9.4 Proof of Proposition 1.3

Agent L discloses if $P \geq P_L^d$ while agent H discloses if $P \geq P_H^d$. We want to find the shares α_L and $\alpha_H = 1 - \alpha_L$ that maximize the range of P in which both agents fully disclose. Hence, we need to find the α_L that minimizes the maximum of the two thresholds P_L^d and P_H^d. We know from (57) and (58) that the threshold P_L^d strictly decreases in α_L and P_H^d strictly increases in α_L. A change in α_L moves the thresholds in opposite directions. Thus, $\max[P_L^d, P_H^d]$ is minimized when the thresholds are just equal:

$$\begin{aligned} P_L^d &= P_H^d \\ \Leftrightarrow \left\{\frac{q[\alpha_L\gamma_L^2 q + 2(1-\alpha_L)\gamma_H^2]}{\alpha_L\gamma_L^2 + 2(1-\alpha_L)\gamma_H^2}\right\}^{1/2} &= \left\{\frac{q[(1-\alpha_L)\gamma_H^2 q + 2\alpha_L\gamma_L^2]}{(1-\alpha_L)\gamma_H^2 + 2\alpha_L\gamma_L^2}\right\}^{1/2} \\ \Leftrightarrow \alpha_L^{dis} &= \frac{\gamma_H^2}{\gamma_H^2 + \gamma_L^2}. \end{aligned} \tag{63}$$

1.9.5 Proof of Proposition 1.4

We show that there exists a P^e for which $\alpha_L^*(P^e) = \frac{1}{2}$ and which lies in the range $[\underline{P}, \bar{P}]$:

1) Derivation of P^e:

$$\alpha_L^*(P^e) = \frac{1}{2} \Leftrightarrow P^e = \left[\frac{q(q\gamma_L^2 + 2\gamma_H^2)}{\gamma_L^2 + 2\gamma_H^2}\right]^{1/2}. \tag{64}$$

2) The threshold P^e lies in the range $[\underline{P}, \bar{P}]$ for all $q \in (0, P)$ and $\gamma_L < \gamma_H \leq 1$:

$$P^e \leq \bar{P} \Leftrightarrow \frac{2q\gamma_L^2\gamma_H^2(\gamma_H^2 - \gamma_L^2)(1-q)}{(\gamma_L^2 + 2\gamma_H^2)(\gamma_L^4 + 2\gamma_H^4)} \geq 0 \tag{65}$$

$$P^e \geq \underline{P} \Leftrightarrow \frac{2q(\gamma_H^2 - \gamma_L^2)(1-q)}{3(\gamma_L^2 + 2\gamma_H^2)} \geq 0. \tag{66}$$

1.9.6 Proof of generality of voting rule

Take any voting rule in which the probability that a project is chosen increases if an agent votes for that project. We denote the probability that project P is implemented given agent i votes for project X and given agent i's expectation about the other agent's vote as ρ_X. ρ_X is higher if an agent votes for project P: $\rho_P > \rho_Q$. An agent then chooses project P if and only if

$$\begin{aligned} \rho_P E_i[U_i^P] + (1-\rho_P)E_i[U_i^Q] &\geq \rho_Q E_i[U_i^P] + (1-\rho_Q)E_i[U_i^Q] \\ \Leftrightarrow (\rho_P - \rho_Q)E_i[U_i^P] &\geq (\rho_P - \rho_Q)E_i[U_i^Q] \\ \Leftrightarrow E_i[U_i^P] &\geq E_i[U_i^Q]. \end{aligned} \tag{67}$$

Hence, agent i votes for the project from which he expects a higher utility.

Since the quality of project P is common knowledge, the expected utility of project P is independent of any additional information agents might have:

$$E_i[U_i^P] = \alpha_i(\alpha_i\gamma_i^2 P + \alpha_j\gamma_j^2 P)P - \frac{1}{2}\alpha_i^2\gamma_i^2 P^2. \tag{68}$$

In contrast, the expected utility of project Q depends on whether an agent received evidence about the quality of project Q. If an agent remains uninformed, his expected utility of project Q takes into account that if the quality of project Q is low, the other agent was informed:

$$\begin{aligned} E_i[U_i^Q](\text{no info}) =& \frac{1-d_j}{3-d_j}[\alpha_i(\alpha_i\gamma_i^2\hat{E}_i[Q] + \alpha_j\gamma_j^2 q)q - \frac{1}{2}\alpha_i^2\gamma_i^2\hat{E}_i[Q]^2] \\ &+ \frac{2}{3-d_j}[\alpha_i(\alpha_i\gamma_i^2\hat{E}_i[Q] + \alpha_j\gamma_j^2\hat{E}_j[Q]) - \frac{1}{2}\alpha_i^2\gamma_i^2\hat{E}_i[Q]^2] \end{aligned} \tag{69}$$

with

$$E_i[Q] = \frac{1-d_j}{3-d_j}q + \frac{2}{3-d_j}. \tag{70}$$

The difference $E_i[U_i^Q](\text{no info}) - E_i[U_i^P]$ is decreasing in P. There is thus a threshold $\tilde{P}$ such that the difference is positive for $P \leq \tilde{P}$. By Assumption 1 ($P \leq E[Q]$) we thus know that $E_i[U_i^Q](\text{no info}) > E_i[U_i^P]$ for all possible P since

$$\begin{aligned} \tilde{P} > E[Q] \Leftrightarrow\ & \alpha_i[7 - d_j + q(5-3d_j)](1+d_j)\gamma_i^2(3-d_i) \\ &+ 2\alpha_j(3-d_j)\gamma_j^2[(3-d_i)(3q+1)d_j + (q+3)d_i + 7 - 3q] > 0. \end{aligned} \tag{71}$$

Hence, if an agent is uninformed, he would vote for project Q.

If an agent is informed and discloses, both agents know the qualities of both projects and will provide individually optimal efforts. The agent will then vote for the project with higher quality, i.e. for project P:

$$\begin{aligned} E_i[U_i^P] &> E_i[U_i^Q](\text{info, disclosed}) \\ \Leftrightarrow \alpha_i(\alpha_i\gamma_i^2 P + \alpha_j\gamma_j^2 P)P - \frac{1}{2}\alpha_i^2\gamma_i^2 P^2 &> \alpha_i(\alpha_i\gamma_i^2 q + \alpha_j\gamma_j^2 q)q - \frac{1}{2}\alpha_i^2\gamma_i^2 q^2 \\ \Leftrightarrow P &> q. \end{aligned} \tag{72}$$

If an agent is informed and does not disclose, his expected utility of project Q takes into account that the other agent forms expectations about the quality of project Q:

$$E_i[U_i^Q](\text{info, concealed}) = \alpha_i(\alpha_i\gamma_i^2 q + \alpha_j\gamma_H^2\hat{E}_j[Q]) - \frac{1}{2}\alpha_i^2\gamma_i^2 q^2. \tag{73}$$

If this was lower than the expected utility of project P, he would have disclosed in the first place, making sure that the other agent also votes for project P.

He knows, if he discloses, that project P will be chosen. If he conceals, the other agent will vote for project Q and hence he can make sure that project Q is chosen by also voting for project Q.

1.9.7 Proof of Lemma 1.2

Throughout this proof, we denote $\alpha_L = \alpha$ and $\alpha_H = 1 - \alpha$. We show with a series of lemmata that at least one agent fully discloses and none of them fully conceals if $P \in [\underline{P}, \sqrt{q})$ and both disclose if $P \geq \sqrt{q}$.

Lemma 1.3. *If $P \geq \underline{P}$, agent L is willing to disclose at least partially.*

Proof. $P_L^c(\alpha)$ is strictly decreasing in α (see 1.9.3) and $P_L^c(\alpha = 0) = \underline{P}$. Hence, $P_L^c(\alpha) \leq \underline{P}$ for all $\alpha \in [0, 1]$. □

Lemma 1.4. *If $P \geq \underline{P}$, agent H is willing to disclose at least partially.*

Proof. $P_H^c(\alpha)$ is strictly increasing in α (see 1.9.3) and $P_H^c(\alpha = 1) = \underline{P}$. Hence, $P_H^c(\alpha) \leq \underline{P}$ for all $\alpha \in [0, 1]$. □

Lemma 1.5. *If $P \geq \underline{P}$, at least one of the agents is willing to fully disclose.*

Proof. For $\alpha \leq \frac{\gamma_H^2}{\gamma_L^2+\gamma_H^2}$, we have $P_H^d(\alpha) \leq \underline{P}$. For $\alpha \geq \frac{\gamma_H^2}{\gamma_L^2+\gamma_H^2}$, we have $P_L^d(\alpha) \leq \underline{P}$. Thus, for all $\alpha \in [0,1]$, $\min[P_L^d(\alpha), P_H^d(\alpha)] \leq \underline{P}$. □

Lemma 1.6. *If $P \geq \sqrt{q}$, both agents are willing to fully disclose, independent of α.*

Proof. $P_L^d(\alpha)$ is strictly decreasing in α (see 1.9.3) and $P_L^d(\alpha = 0) = \sqrt{q}$. Hence, $P_L^d(\alpha) \leq \sqrt{q}$ for all $\alpha \in [0,1]$. $P_H^d(\alpha)$ is strictly increasing in α (see 1.9.3) and $P_H^d(\alpha = 1) = \sqrt{q}$. Hence, $P_H^d(\alpha) \leq \sqrt{q}$ for all $\alpha \in [0,1]$. □

These Lemmata imply that in the range $P \in [\underline{P}, \sqrt{q})$, three types of equilibria can arise: both agents disclose, agent L discloses while agent H mixes and agent L mixes while agent H discloses. In the range $P \in [\sqrt{q}, E[Q])$, both agents always fully disclose information.

1.9.8 Proof of Proposition 1.5

Throughout this proof, we denote $\alpha_L = \alpha$ and $\alpha_H = 1 - \alpha$.

We showed in Section 1.5.1 that $\underline{\alpha}$ is optimal in the range $\alpha \in [\underline{\alpha}, \bar{\alpha}]$, i.e. if there is full disclosure.

If $\alpha \leq \underline{\alpha}$, agent L starts concealing partially. We prove in 1) that the surplus when agent H is disclosing and agent L partially conceals is concave in α. We also show that it is strictly increasing at $\underline{\alpha}$ for $P \in [\hat{P}, \bar{P}]$, with $\hat{P} \in [\underline{P}, \bar{P}]$. Hence, for such P, $\alpha < \underline{\alpha}$ would yield lower surplus than $\underline{\alpha}$. $\underline{\alpha}$ brings us back to full disclosure. For $P \in [\underline{P}, \hat{P}]$, $\alpha < \underline{\alpha}$ would yield higher surplus than $\underline{\alpha}$ and hence some concealment is optimal.

If $\alpha \geq \bar{\alpha}$, agent H starts concealing partially. We prove in 2) that surplus is decreasing at $\alpha \geq \bar{\alpha}$ for all $P \in [\underline{P}, \bar{P})$. Hence, the maximal surplus we get for $\alpha \in [\bar{\alpha}, 1]$ is at $\bar{\alpha}$. Since we are then back to full disclosure, $\underline{\alpha}$ would yield a higher surplus.

1) Proof that $\underline{\alpha}$ is optimal in $[0,\underline{\alpha}]$ if $P \in [\hat{P}, \sqrt{q})$.

We denote the surplus if agent L mixes and agent H discloses fully as

$$\begin{aligned} S_{md} = &\ \frac{1}{4}(1+d_L)S_P[e_L(P), e_H(P)] \\ &+ \frac{1}{4}(1-d_L)S_q[e_L(q), e_H(\hat{E}_H[Q])] \\ &+ \frac{1}{2}S_1[e_L(\hat{E}_L[Q]), e_H(\hat{E}_H[Q])]. \end{aligned} \tag{74}$$

We first show that this surplus is concave in α for $P \geq \underline{P}$. Then we find conditions for the surplus to be increasing in α at $\underline{\alpha}$.

Surplus S_{md} is strictly concave in α for $P \geq \underline{P}$

Take the second derivative:

$$\begin{aligned} \frac{\partial^2 S_{md}}{\partial \alpha^2} =& \frac{1}{4}\frac{\partial^2 d_L}{\partial \alpha^2}\{S_P[e_L(P), e_H(P)] - S_q[e_L(q), e_H(\hat{E}_H[Q])]\} \\ &+ \frac{1}{2}\frac{\partial^2 S_1[e_L(\hat{E}_L[Q]), e_H(\hat{E}_H[Q])]}{\partial \alpha^2} \\ &+ \frac{1}{2}\frac{\partial d_L}{\partial \alpha}\left[\frac{\partial S_P[e_L(P), e_H(P)]}{\partial \alpha} - \frac{\partial S_q[e_L(q), e_H(\hat{E}_H[Q])]}{\partial \alpha}\right] \\ &+ \frac{1}{4}(1+d_L)\frac{\partial^2 S_P[e_L(P), e_H(P)]}{\partial \alpha^2} \\ &+ \frac{1}{4}(1-d_L)\frac{\partial^2 S_q[e_L(q), e_H(\hat{E}_H[Q])]}{\partial \alpha^2}. \end{aligned} \tag{75}$$

The second derivative depends on P only via P^2. We therefore replace P^2 by x and get a new function $C(x)$ where $C(P^2) = \frac{\partial^2 S_{md}}{\partial \alpha^2}(P)$. Note that, if $C(x^*) = 0$ then $\frac{\partial^2 S_{md}}{\partial \alpha^2}(P^*) = 0$ with $P^* = \sqrt{x^*}$. Furthermore $C(x) > 0 \Leftrightarrow \frac{\partial^2 S_{md}}{\partial \alpha^2}(P) > 0$ for $P = \sqrt{x}$. Therefore, by showing that $C(x)$ is negative for $x \in [\underline{P}^2, E[Q]^2)$, we also show that $\frac{\partial^2 S_{md}}{\partial \alpha^2}(P)$ is negative for $P \in [\underline{P}, E[Q])$.

We can indeed show that $C(x)$ is negative for $x \in [\underline{P}^2, E[Q]^2)$ by proving that 1) C strictly decreases in x and 2) C is strictly negative at $x = \underline{P}^2$.

Hence it is strictly negative also for all $x > \underline{P}^2$. This implies that the second derivative is strictly negative for $P \in [\underline{P}, E[Q])$.

1) C strictly decreases in x:

$$\frac{\partial C}{\partial x} = -\frac{5}{4}\frac{[2-(2-\gamma^2)\alpha]^3[(\gamma^2+\frac{2}{5})q+\frac{1}{5}(2-\gamma^2)]}{q[\alpha\gamma^2+2(1-\alpha)]^3} < 0. \tag{76}$$

2) At $x = \underline{P}^2$, $C(x)$ is strictly negative:

$$T \equiv \frac{4}{5}q[\alpha\gamma^2+2(1-\alpha)]^3 C(\underline{P}^2). \tag{77}$$

Whenever T is strictly negative, $C(\underline{P}^2)$ is strictly negative too. We can show that T is strictly concave in α:

$$\frac{\partial^2 T}{\partial \alpha^2} = -\frac{8}{5}[\alpha\gamma^2+2(1-\alpha)]q(2-\gamma^2)(\gamma^2+1) \\ [(1+\gamma^2)q^2+3q(1-\gamma^2)+2-\gamma^2] < 0. \tag{78}$$

At $\alpha = 1$, T is still increasing and negative:

$$\left.\frac{\partial T}{\partial \alpha}\right|_{\alpha=1} = \frac{4}{5}q\gamma^4(\gamma^2+1)[(\gamma^2+1)q^2+3(1-\gamma^2)q+2-\gamma^2] > 0, \tag{79}$$

$$T(\alpha=1) = -\frac{4}{15}q\gamma^6[(3\gamma^2-4q+6)q+\gamma^2(1-q^2)+1] < 0. \tag{80}$$

Hence, $T < 0$ for all $\alpha \leq 1$. This implies that $C(\underline{P}^2) < 0$ for $\alpha \in [0,1]$.

We showed that $C(x)$ is strictly decreasing in x and already strictly negative at $x = \underline{P}^2$. This implies that S_{md} is strictly concave in α for $P \geq \underline{P}$.

Surplus S_{md} is increasing in α at $\underline{\alpha}$ if $P \in [\hat{P}, \sqrt{q}]$ with $\hat{P} \in (\underline{P}, \bar{P})$.

We want to show that the derivative of S_{md} wrt α at $\underline{\alpha}$ ($=S'_{md}(\underline{\alpha})$) is positive if the quality of project P is high enough. Define

$$D(x) \equiv 8q(1-q)[2(q-x)+\gamma^2(x-q^2)]S'_{md}(\underline{\alpha}, P) \tag{81}$$

with $x = P^2$. Given $x \in [\underline{P}^2, q]$, in order to show that $S'_{md}(\underline{\alpha})$ is positive at a certain P, we need to show that $D(x)$ is positive at $x = P^2$.

We first observe (a) that $D(x)$ is strictly increasing in x for $x \in [\underline{P}^2, q]$. Then we show in (b) that $D(x)$ is strictly positive at $x = \bar{P}^2$ and in (c) that $D(x)$ is strictly negative at $x = \underline{P}^2$ if $q > \bar{q}$. These observations tell us that if $q > \bar{q}$ there exists a threshold $\hat{x} = \hat{P}^2 \in (\underline{P}^2, \bar{P}^2)$ such that $D(x) > 0$ if and only if $x \in [\hat{P}^2, q)$, which implies $S'_{md}(\underline{\alpha}) > 0$ if and only if $P \in [\hat{P}, \sqrt{q})$. When $q < \bar{q}$, $D(x) > 0$ for all $x \in [\underline{P}^2, q)$ and thus $S'_{md}(\underline{\alpha}) > 0$ for all $P \in [\underline{P}, \sqrt{q})$.

a) $D(x)$ is strictly increasing in x:

The first derivative of $D(x)$ wrt x is convex x:

$$\frac{\partial^3 D(x)}{\partial x^3} = 18\gamma^2(2 - \gamma^2) > 0, \tag{82}$$

already increasing and positive at $x = \underline{P}^2$:

$$\left.\frac{\partial^2 D(x)}{\partial x^2}\right|_{\underline{P}^2} = 2(1-q)[(8+\gamma^4)(1+q) - 6\gamma^2] > 0. \tag{83}$$

$$\left.\frac{\partial D(x)}{\partial x}\right|_{\underline{P}^2} = \frac{4}{3}q(1-q^2)[(4-\gamma^4)q + 4\gamma^4 + 2 - \frac{3}{2}\gamma^2(1-q)] > 0. \tag{84}$$

Hence the first derivative with respect to x is strictly positive for all $x \geq \underline{P}^2$.

b) $D(x)$ is strictly positive at $x = \bar{P}^2$:

$$D(\bar{P}^2) = \frac{8q^2(1-q)^3(1+\gamma^2)\gamma^4[1 + 2\gamma^2 + \gamma^6 + \frac{1}{2}\gamma^4(1+3q)]}{(\gamma^4+2)^3} > 0. \tag{85}$$

c) $D(x)$ is strictly negative at $x = \underline{P}^2$ if $q > \bar{q}$:

$$\begin{aligned} D(\underline{P}^2) &= \frac{4}{9}(1+\gamma^2)q^2(1-q)^2[7\gamma^2 - 4 - (2-\gamma^2)q^2 - (6-4\gamma^2)q] < 0 \\ &\Leftrightarrow 0 > 7\gamma^2 - 4 - (2-\gamma^2)q^2 - (6-4\gamma^2)q \\ &\Leftrightarrow \gamma < \sqrt{\frac{2(2+3q+q^2)}{7+4q+q^2}} \equiv \underline{\gamma}(q). \end{aligned} \tag{86}$$

Homogeneity γ must be low enough to make it negative. If γ is low enough $\gamma < \underline{\gamma}(q)$, there exists a unique $\hat{P} \in (\underline{P}, \bar{P})$ for which $S'_{md}(\underline{\alpha}, \hat{P}) = 0$. The threshold $\underline{\gamma}(q)$ is strictly increasing in q:

$$\frac{\partial \underline{\gamma}(q)}{\partial q} = \frac{13 + 10q + q^2}{2^{1/2}(7 + 4q + q^2)^{3/2}(2 + 3q + q^2)^{1/2}} > 0, \tag{87}$$

2) Proof that $\bar{\alpha}$ is optimal in $[\bar{\alpha}, 1]$

The ex-ante expected total surplus of the team if agent L always discloses and agent H discloses with probability d_H is

$$\begin{aligned} S_{dm} =& \frac{1}{4}(1 + d_H)S_P[e_L(P), e_H(P)] + \frac{1}{4}(1 - d_H)S_q[e_L(\hat{E}_L[Q]), e_H(q)] \\ &+ \frac{1}{2}S_1[e_L(\hat{E}_L[Q]), e_H(\hat{E}_H[Q])]. \end{aligned} \tag{88}$$

We want to show that S_{dm} is decreasing for $\alpha \in [\bar{\alpha}, 1]$ in the range $P \in [\underline{P}, \sqrt{q})$. α^{dis} is the lowest share for which the equilibrium in which L fully discloses and H mixes exists given $P \geq \underline{P}$. If α was smaller ($\alpha < \alpha^{dis}$), agent H would want to disclose for all $P \geq \underline{P}$, i.e. $P_H^d(\alpha) < \underline{P}$. Hence, $\bar{\alpha} \geq \alpha^{dis}$ and therefore it is sufficient to show that S_{dm} is decreasing for $\alpha \in [\alpha^{dis}, 1]$.

Surplus S_{dm} is strictly decreasing for $\alpha \in [\alpha^{dis}, 1]$

Consider the first derivative of S_{dm} with respect to α:

$$\begin{aligned} S'_{dm} = \frac{\partial S_{dm}}{\partial \alpha} =& \frac{1}{4}\frac{\partial d_H}{\partial \alpha}\{S_P[e_L(P), e_H(P)] - S_q[e_L(\hat{E}_L[Q]), e_H(q)]\} \\ &+ \frac{1}{4}(1 + d_H)\frac{\partial S_P[e_L(P), e_H(P)]}{\partial \alpha} \\ &+ \frac{1}{4}(1 - d_H)\frac{\partial S_q[e_L(\hat{E}_L[Q]), e_H(q)]}{\partial \alpha} \\ &+ \frac{1}{2}\frac{\partial S_1[e_L(\hat{E}_L[Q]), e_H(\hat{E}_H[Q])]}{\partial \alpha}. \end{aligned} \tag{89}$$

While the first term is negative, the other terms can be positive or negative. It is thus difficult to show directly that S'_{dm} is negative. However, we can show that it is convex in α:

$$\frac{\partial^2 S'_{dm}}{\partial \alpha^2} = \frac{9\gamma^4 q(1-q)}{[2\alpha\gamma^2 + (1-\alpha)]^4} > 0. \tag{90}$$

We thus only have to show that S'_{dm} is negative at $\alpha = \alpha^{dis}$ and $\alpha = 1$.

1) S'_{dm} is negative at $\alpha = \alpha^{dis}$:

$$\begin{aligned} S'_{dm}(\alpha^{dis}) = -&\frac{1}{24(1+\gamma^2)q^2}\{(2\gamma^4 - 5)q^4 - (\gamma^2+7)q^3 \\ &+ [12 + (4\gamma^6 - 8\gamma^4 - 15\gamma^2 + 21)P^2]q^2 \\ &+ P^2(3 - 12\gamma^4 + 9\gamma^2)q - 3P^4(2\gamma^2 - 1)\gamma^2\}. \end{aligned} \tag{91}$$

We replace $x = P^2$ and hence have to show that $S'_{dm}(\alpha^{dis})$ is strictly negative for all $x \in [\underline{P}^2, q]$. Take the second derivative wrt to x:

$$\frac{\partial^2 S'_{dm}(\alpha^{dis})}{\partial x^2} = \frac{1}{2}\frac{(\gamma^2 - \frac{1}{2})\gamma^2}{(1+\gamma^2)q^2}. \tag{92}$$

The second derivative is positive if $\gamma^2 > \frac{1}{2}$ and negative if $\gamma^2 < \frac{1}{2}$. If it is negative ii), $S'_{dm}(\alpha^{dis})$ is concave in x and we have to show that it is decreasing and negative at $x = \underline{P}^2$. If it is positive iii), $S'_{dm}(\alpha^{dis})$ is convex in x and we have to show that it is negative at $x = \underline{P}^2$ and at $x = q$.

i) $S'_{dm}(\alpha^{dis})$ is strictly negative for all x if $\gamma^2 = \frac{1}{2}$:

$$\begin{aligned} S'_{dm}(\alpha^{dis}, \gamma^2 = \frac{1}{2}) = \\ -\frac{3q(1-q^2) + 5q(1-q) + (8q+3)x}{24q} < 0. \end{aligned} \tag{93}$$

ii) $S'_{dm}(\alpha^{dis})$ is strictly negative for all $x \in [\underline{P}^2, \bar{P}^2]$ if $\gamma^2 < \frac{1}{2}$:

If $\gamma^2 < \frac{1}{2}$, $S'_{dm}(\alpha^{dis})$ is strictly concave in x. In this case we have to show that $S'_{dm}(\alpha^{dis})$ is a) decreasing in x at $x = \underline{P}^2$ and b) negative at $x = \underline{P}^2$.

a) $S'_{dm}(\alpha^{dis})$ is strictly decreasing in x at $x = \underline{P}^2$ for $q > 0$:

$$\begin{aligned}
&\left.\frac{\partial S'_{dm}(\alpha^{dis})}{\partial x}\right|_{\underline{P}^2} < 0 \\
\Leftrightarrow &- \frac{3 + 13\gamma^2 - 20\gamma^4 + q(4\gamma^6 - 12\gamma^4 - 13\gamma^2 + 21)}{24(1+\gamma^2)q} < 0 \\
\Leftrightarrow &q > \frac{20\gamma^4 - 13\gamma^2 - 3}{4\gamma^6 - 12\gamma^4 - 13\gamma^2 + 21}. \qquad (94)
\end{aligned}$$

This threshold for q is strictly negative for $\gamma^2 < \frac{1}{2}$: Define $T(z) \equiv \frac{20z^2-13z-3}{4z^3-12z^2-13z+21}$. Then we have to show that $T(z) < 0$ for $z < \frac{1}{2}$. The denominator DN is always strictly positive since it is concave in z ($DN'' = -24(1-z)$) and it is strictly positive at $z = 0$ (DN(z=0)=21) and at $z = \frac{1}{2}$ (DN(z=1/2)=12). The nominator N is strictly negative since it is convex in z ($N'' = 40$) and strictly negative at $z = 0$ ($N(z = 0) = -3$) and $z = \frac{1}{2}$ ($N(z = 1/2) = -\frac{9}{2}$) and hence also for all $z = \gamma^2 \in (0, \frac{1}{2})$.

b) $S'_{dm}(\alpha^{dis})$ is strictly negative at $x = \underline{P}^2$:

$$\begin{aligned}
S'_{dm}(\alpha^{dis}, \underline{P}^2) = \; & -\frac{1}{36(1+\gamma^2)}[(2q^2+4q)\gamma^6 \qquad (95)\\
& - (2q^2 + 18q + 16)\gamma^4 \\
& + (11 - 7q^2 - 10q)\gamma^2 + 3q^2 + 12q + 21].
\end{aligned}$$

We replace $z = \gamma^2$ and then have to show that R is strictly positive for $z < \frac{1}{2}$:

$$\begin{aligned}
R \equiv \; & (2q^2+4q)z^3 - (2q^2+18q+16)z^2 \qquad (96)\\
& + (11 - 7q^2 - 10q)z + 3q^2 + 12q + 21 > 0.
\end{aligned}$$

R is strictly concave in z ($R'' = -[4(8-3q^2z) + 12q(3-2z) + 4q^2]$) and strictly positive at $z = 0$ ($R(z = 0) = 3q^2 + 12q + 21$)

and at $z = 1$ ($R(z = 1) = 16 - 4q^2 - 12q$). Hence, $R > 0$ for all $z \in [0, 1]$.

It follows that $S'_{dm}(\alpha^{dis}, \underline{P}^2) < 0$ for $q \in [0, p]$ and $z \in [0, 1]$.

iii) $S'_{dm}(\alpha^{dis})$ is strictly negative for all $x \in [\underline{P}^2, q]$ if $\gamma^2 > \frac{1}{2}$:

If $\gamma^2 > \frac{1}{2}$, $S'_{dm}(\alpha^{dis})$ is strictly convex in x. We just showed that $S'_{dm}(\alpha^{dis})$ is strictly negative at $x = \underline{P}^2$ for $\gamma^2 \in [0, 1]$. Hence, we are left to show that $S'_{dm}(\alpha^{dis})$ is also strictly negative at $x = q$. Convexity then implies that $S'_{dm}(\alpha^{dis})$ is strictly negative for all $x \in [\underline{P}^2, q]$.

$$S'_{dm}(\alpha^{dis}, q) = \frac{(18 + 8q - 2q^2)\gamma^4 - 4q\gamma^6 + (16q - 12)\gamma^2 + 5q^2 - 14q - 15}{24(1 + \gamma^2)}. \tag{97}$$

We can show that this is a) strictly convex in q, b) strictly negative at $q = 0$ and c) strictly negative at $q = 1$:

a) $S'_{dm}(\alpha^{dis}, q)$ is strictly convex in q:

$$\frac{\partial^2 S'_{dm}(\alpha^{dis}, q)}{\partial q^2} = \frac{5 - 2\gamma^4}{12(1 + \gamma^2)} > 0. \tag{98}$$

b) $S'_{dm}(\alpha^{dis}, q)$ is strictly negative at $q = 0$:

$$S'_{dm}(\alpha^{dis}, q, q = 0) = -\frac{15 + 12\gamma^2 - 18\gamma^4}{24(1 + \gamma^2)} < 0. \tag{99}$$

c) $S'_{dm}(\alpha^{dis}, q)$ is non-positive at $q = 1$:

$$S'_{dm}(\alpha^{dis}, q, q = 1) = -\frac{(24 - 4\gamma^2)(1 - \gamma^4)}{24(1 + \gamma^2)} < 0. \tag{100}$$

2) S'_{dm} is strictly negative at $\alpha = 1$:

$$S'_{dm}(\alpha = 1) = -\frac{1}{8q}[7P^2 q + P^2 + 4q(1 - q)]. \tag{101}$$

We showed that the surplus is decreasing in α. Hence, it is optimal to choose $\bar{\alpha}$.

1.9.9 Proof of Proposition 1.6

Throughout this proof, we denote $\alpha_L = \alpha$ and $\alpha_H = 1 - \alpha$. P^e (defined by $\alpha^*(P^e) = \frac{1}{2}$) lies in the range $[\hat{P}, \bar{P}]$, if and only if $S'_{md}(\bar{\alpha})$ is increasing at P^e. We show that this is true whenever $\gamma^2 > \sqrt{6} - 2$ and $q < \tilde{q}$. If these conditions are fulfilled, equal sharing is optimal at P^e.

$S'_{md}(\underline{\alpha})$ is positive at P^e if $\gamma^2 > \sqrt{6} - 2$ and $q < \tilde{q} \in (0, 1]$:

$$S'_{md}(\underline{\alpha}, P^e) = \frac{(q^2+1)\gamma^6 + (6 - 2q^2 + 2q)\gamma^4 + (6 - 2q^2 - 4q)\gamma^2 - 4q - 4}{4(\gamma^2+2)^2}. \tag{102}$$

This is strictly decreasing in q:

$$\frac{\partial S'_{md}(\underline{\alpha}, P^e)}{\partial q} = -\frac{(4 - 2\gamma^2)q\gamma^4 + (4 - 2\gamma^2)\gamma^2 + 4q\gamma^2 + 4}{4(\gamma^2+2)^2} < 0. \tag{103}$$

$S'_{md}(\underline{\alpha}, P^e)$ is strictly positive at $q = 0$ if $\gamma^2 > \sqrt{6} - 2 \approx 0.4495$. It is strictly negative at $q = 1$ if $\gamma^2 < 1$. Hence, if $\gamma^2 > \sqrt{6} - 2$, there exists a threshold $\tilde{q} \in (0, 1)$ such that $S'_{md}(\underline{\alpha}, P^e) > 0$ if $q < \tilde{q}$:

$$\tilde{q} = \frac{(4 - \gamma^{12} - 4\gamma^{10} + 9\gamma^8 + 24\gamma^6 + 4\gamma^4)^{1/2}}{\gamma^2(2 + 2\gamma^2 - \gamma^4)} - \frac{1}{\gamma^2}. \tag{104}$$

If $\gamma^2 < \sqrt{6} - 2$, $S'_{md}(\underline{\alpha}, P^e)$ is negative for all q, so equal shares are not optimal.

1.9.10 Proofs when different ability to receive information

We assume that given project Q is of low quality, agents receive information with independent probabilities $\pi_L \in (0, 1)$ and $\pi_H \in (0, 1)$. Agent i discloses information iff

$$\begin{aligned} U_i^d(\boldsymbol{\alpha}, P, e_i(P), e_j(P)) \geq \quad & \pi_j d_j U_i^d(\boldsymbol{\alpha}, P, e_i(P), e_j(P)) \\ & + \pi_j(1-d_j)U_i^c(\boldsymbol{\alpha}, q, e_i(q), e_j(q)) \\ & + (1-\pi_j)U_i^c(\boldsymbol{\alpha}, q, e_i(q), e_j(\hat{E}_j[Q])). \end{aligned} \tag{105}$$

While agent i knows that quality is q, agent j might remain uninformed and has to form expectations over the quality of project Q. Agent i knows that if agent j remained uninformed, by Basian updating, he will believe quality of project Q is

$$\hat{E}_j[Q] = \frac{(1-d_i\pi_i)(1-\pi_j)q+1}{(1-d_i\pi_i)(1-\pi_j)+1}. \tag{106}$$

Agent i discloses iff $P \geq P_i^d$, with

$$P_i^d = \left[\frac{q\{q\alpha_i\gamma_i^2[2-\pi_i-\pi_j(1-\pi_i)] + 2\alpha_j\gamma_j^2[1+(1-\pi_j)(1-\pi_i)q]\}}{(\alpha_i\gamma_i^2+2\alpha_j\gamma_j^2)[2-\pi_i-\pi_j(1-\pi_i)]}\right]^{1/2}. \tag{107}$$

This threshold decreases in an agent's own share α_i and increases in the other agent's share α_j:

$$\frac{\partial P_i^d}{\partial \alpha_i} = -\frac{2\gamma_i^2\gamma_j^2\alpha_j q(1-q)}{(\alpha_i\gamma_i^2+2\alpha_j\gamma_j^2)^2[2-\pi_i-\pi_j(1-\pi_i)]} < 0, \tag{108}$$

$$\frac{\partial P_i^d}{\partial \alpha_j} = \frac{2\gamma_i^2\gamma_j^2\alpha_i q(1-q)}{(\alpha_i\gamma_i^2+2\alpha_j\gamma_j^2)^2[2-\pi_i-\pi_j(1-\pi_i)]} > 0. \tag{109}$$

Consider the benchmark of symmetrically informed agents (equivalent to full disclosure). The probability that they remain uninformed even though the quality of project Q is low is $(1-\pi_L)(1-\pi_H)$. If agents remain uninformed, they update beliefs about the quality of project Q to (106) with $d_L = d_H = 1$. In this situation, $\boldsymbol{\alpha}^{sym}$ maximizes the team's surplus.

Chapter 2

Price Discrimination and Salience-Driven Consumer Preferences

2.1 Introduction

Evidence from field and laboratory experiments suggests that preferences can vary with the context (e.g. Kahneman et al., 1990; Simonson and Tversky, 1992). For example, introducing a dominated product might increase another product's demand, giving rise to the so-called decoy (Huber et al., 1982) and compromise (Simonson, 1989) effects. Such context effects cannot be explained by standard preferences since the presence of a product should leave consumer choice between the other products unaffected.

One possible way of explaining context effects is the assumption that consumers attach a higher weight to the attributes of a product that are salient and the salience of the attributes depends on the context.

There is evidence for the effect of salience on the weights given to different attributes. Chetty et al. (2009) find evidence that consumers underreact to changes in taxes if taxes are not salient. Hossain and Morgan (2006), studying the behavior of consumers on eBay, argue that shipping costs are less salient than opening bids. They show that consumers indeed react less to changes in shipping costs than to changes in opening bids. Recent results in neuroeconomics are consistent with the idea that attention modulates the weight given to different attributes (Hare et al., 2009; Fehr and Rangel, 2011). Marketing practitioners engage frequently in differentiating from their competitors' by drawing attention to certain attributes of their products (Zhou, 2008).

Evidence shows that salience depends on how much attributes vary within the choice set. Schkade and Kahneman (1998) consider the choice between living in California and the Midwest and show that individuals place a higher weight on attributes that differ strongly across these two options.

Imagine a supermarket offers two versions of whiskey. They are both single malt whiskeys but differ in their age, with higher age being associated with higher quality. The lower quality version is 12 years old while the higher quality whiskey was in the barrel for 18 years. They are offered for \$30 and \$40, respectively. A consumer values the younger version at 36 and the older version at 54. If the consumer has standard quasi-linear preferences, he prefers the older whiskey since it yields a higher utility. If a consumer has salience-driven preferences, the high quality difference attracts the consumer's attention. The older version is 50% more valuable than the younger version but it is only 30% more expensive. Since quality gets more attention, i.e. since quality is salient, the consumer gives a higher weight to this attribute which makes the older whiskey even more attractive. A couple of weeks later, the same consumer enters the supermarket and finds the two whiskeys are on sale. They are now offered at $15 and $25, respectively. The price difference and the quality difference are still the same. A consumer with standard preferences would again opt for the older whiskey. However, the difference in price now stings out. While the older version is still 50% more valuable, it is now 66.7% more expensive than the younger version. Price is salient to a consumer with salience-driven preferences and thus gets a higher weight. The consumer is not willing to pay the extra $10 anymore and buys the younger whiskey. In this whiskey example, the attention and weight a consumer gives to an attribute depends on whether an offer seems to be a good deal, i.e. has a good quality-price ratio.

Such behavior can be explained by the salience-driven preferences of Bordalo et al. (2013b). In an influential paper, they have proposed a model of salient thinking which incorporates these observations. In their model, consumers give a higher weight to more salient attributes of a product. The salience of an attribute depends on the difference of the attribute's value to the average value of the attribute within the choice set. This implies a context effect because each attribute's average value depends on all products that are offered. If products are defined by only two attributes, quality and price, the model provides the intuitive result that consumers' preferences are biased towards the product with the higher quality-price ratio.

Salient thinking becomes relevant as soon as there is more than one product in the market. Consequently, Bordalo et al. (2016) study the implications of salience-driven consumer preferences for competing firms. However, there is another situation in which several products may coexist. In a market with heterogeneous preferences, a monopolist may offer multiple products in order to separate different types of consumers. It remains an open question how a multi-product monopolist would react to salient thinking if consumers are heterogeneous in their valuation of quality.

Continuing with the example, consider a second type of consumer who has a higher valuation of whiskey. This type values the 12 years old whiskey at 40 and the 18 years old whiskey at 60. Being aware of the differences in valuations, the supermarket can adopt different strategies. He can try to pool both types of consumers either on the young or on the old version of whiskey. Alternatively, the supermarket can choose prices and qualities such that the high valuation type self-selects into buying the old whiskey, while the low type buys the young version. Finally, the supermarket can exclude the low type and only sell one version of the whiskey at a high price. When choosing its strategy, the supermarket has to take into account that the design of its products also influences whether its customers focus on the price or on the age of the whiskeys.

This paper is interested in a monopolist's optimal design of a product portfolio, taking into account its effect on the salience of attributes. It looks at the situation when two versions of the product are possible, e.g. 12 years old and 18 years old whiskey. If the monopolist decides only to sell one version of the product, he could additionally offer a "decoy", i.e. a second version of the product that manipulates consumer's focus without actually being sold. In a next step, I consider the possibility to offer more variants of the product.

In order to investigate the optimal strategy of a monopolist, I introduce the salience-driven consumer preferences of Bordalo et al. (2013b) into the standard monopolist price discrimination model of Mussa and Rosen (1978). A monopolist offers a product portfolio with products that are characterized by their qualities and prices. There are two types of consumers with different valuations of quality. As in Mussa and Rosen (1978), a consumer's valuation of quality is proportional to his type. Consumers have salience-driven preferences, i.e. they give a higher weight to the attribute which is salient. Following Bordalo et al. (2013b), when consumers compare two products, they give a higher weight to quality if and only if the high-quality product has a higher quality-price ratio. Giving a higher weight to quality increases a consumer's willingness to pay since they overestimate the quality. Focussing on price decreases the willingness to pay since it lets consumers overestimate the costs.

The first result of this paper is that in comparison with the benchmark case of consumers with standard preferences, we observe less separation if consumers have salience-driven preferences. Separation of consumers with salience-driven preferences is less profitable than if consumers had standard preferences. At the same time, profits from pooling and excluding low types increase. Assuming that the monopolist faces consumers with standard preferences thus overestimates his propensity to employ price discrimination. Furthermore, when separating consumers with salience-driven preferences, there is a "distortion at the top" in the sense that in case of separation, the monopolist offers a lower quality to the high type than he would if this type was alone in the market.

In a market with two products, the same attribute is salient for both products (Bordalo et al., 2013b). Generally, allowing for heterogeneous consumers entails the possibility that different types focus on different attributes. However, in the simple case of linear preferences as in Mussa and Rosen (1978), all consumers focus on the same attribute. Hence, it becomes a sensible question to ask under what conditions we will observe a price-salient or a quality-salient market.

Which attribute is salient relates directly to the optimal strategy of the monopolist. If there is separation in the market, consumers always focus on price. Separation is optimal for an intermediate range of heterogeneity and share of high types. If there is pooling or exclusion of low types in the market, consumers always focus on quality. This is optimal when heterogeneity is low and the share of high types is large or when heterogeneity is high and the share of high types is low.

For our whiskey example, this implies that a supermarket should optimally adapt the strategy to changes in valuations and share of high types. Assume that during the week, there are few high types. It would thus be optimal to pool the types on the older whiskey and offer the younger version with only a small reduction in price. The younger whiskey serves to attract consumers' attention towards quality. At the weekend, more consumers have a high valuation of alcoholic drinks, which makes it more profitable to separate. In order to separate the high and the low type, the supermarket makes the older whiskey relatively more expensive and the customers focus on the high price difference. Suppose that after a couple of weeks, the share of high value consumers has increased. This new development makes it more profitable for the supermarket to exclude the few low types and sell the older whiskey only to the high types. It decreases the difference in price, which makes consumers focus on quality.

If the monopolist can offer more products, he might be able to separate consumers while making quality salient. It turns out that it is not always possible to find three products which make the optimally separating products quality salient. However, if the monopolist is not restricted in the number of products, he can always induce quality salience in the market by offering multiple decoys. Hence, the model predicts separation with quality salience if development costs of such decoys are low and separation with price salience if development costs are high. As long as development costs are non-zero, the monopolist is less likely to separate than in the benchmark case with standard preferences.

Hence, this paper provides an explanation for the observation that there is little price discrimination even in settings in which we expect consumers to be heterogeneous as e.g. in cinemas or theaters (Huntington, 1993; Leslie, 2004). Pooling is more likely to be observed if there are many consumers with low valuation in the market and heterogeneity is not too high. This is in line with the observation that motels often only offer one category while hotels or airlines offer several categories in order to price discriminate (Hahn et al., 2018).

The rest of the paper is structured as follows. Section 2.2 reviews the literature on standard price discrimination and price discrimination when consumers have non-standard preferences. Section 2.3 presents the model, including a review of the salience model of Bordalo et al. (2013b). In Section 2.4, the benchmark with consumers with standard preferences is considered. Section 2.5 derives the optimal strategy of a monopolist facing consumers with salience-driven preferences and Section 2.6 presents some robustness results. Section 2.7 concludes.

2.2 Related literature

2.2.1 Price discrimination with standard preferences

Price discrimination can be defined as the strategy to offer two or more similar goods at prices that are in different ratios to marginal costs (e.g. books in hardcover and in paperback) (Varian 1989, p.598). Such price discrimination can be observed in situations of imperfect information, i.e. when consumers have different types and a firm cannot directly observe these types. However, the distribution of these types is common knowledge. In order to maximize profits, a monopolist can offer several products and choose the design in such a way that different types of consumers choose different versions of the product. Price discrimination can occur for example in terms of quality, quantity or intertemporally.

One of the first papers studying this problem was Mussa and Rosen (1978). They consider a consumer's utility function $u(q, p; \theta) = \theta q - p$, where q is the quality and p the price of a product. Consumers differ in their valuation of quality θ. Mussa and Rosen (1978) solve the monopolist's problem and compare the offered products under monopoly with the offered products under competition. When there are only two types of consumers and the monopolist wants to separate, he offers the efficient quality to the type with the higher valuation, i.e. the same quality as under competition or perfect information. It is a very general result, that the consumer type with the highest valuation of quality faces a marginal price equal to marginal costs (Varian 1989, p.614). Such "no distortion at the top" is usually also true if interpreted as the same quality being offered to the highest type as if this type was alone in the market. However, this result does not hold if consumers exhibit salient thinking and the monopolist is restricted to two products. If separation is optimal, price is salient and the quality which is offered to the high type is lower than in the absence of the low type. If there was only the high type, the monopolist could offer products which make quality salient and would offer a higher quality.

In the case of two consumer types, the monopolist separates consumers with standard preferences with a high-quality product which has a lower quality-price ratio than the low-quality product. Considering salience-driven preferences, the separation of types also requires offering the higher quality product at a lower quality-price ratio. However, if the monopolist wants to pool both types on the high-quality product or exclude low types, it is optimal for him to offer the higher quality product at a higher quality-price ratio. This allows the monopolist to make consumers focus on quality.

2.2.2 Price discrimination with non-standard preferences

In recent years, a considerable literature on monopolistic price discrimination with consumers with non-standard preferences has developed. Typically, consumers exhibit some behavioral bias and the monopolist can try to exploit and benefit from this bias. In the case of context-dependent preferences, the monopolist has to take into account his influence on the context. The monopolist then often benefits from offering a "decoy", i.e. an additional product that is not meant to be sold but affects the attention of consumers.

Closest to this paper are papers which consider the monopolist's problem when the relative weights which consumers give to attributes depend on the attributes of the offered products. Consumers weight attributes according to a specific rule, i.e. there is no strategic attention allocation. Dahremöller and Fels (2015) assume that consumers give higher weights to attributes which they value strongly and which vary strongly in the choice set. Furthermore, the cost of considering an additional attribute increases in the number of considered attributes. They show how a monopolist benefits from offering different products even if consumers are homogeneous because it manipulates the expectations of consumers. Considering heterogeneous consumers, they restrict attention to the case in which the monopolist can only offer two products with attributes quality and price. If the optimal products separate the types, the type with high valuation of quality will focus on quality while the type with low valuation focuses on price. The monopolist will thus over-provide quality for the high type and under-provide quality for the low type. This is different to the results of this paper, which say that when the monopolist can only offer two products, separation implies that both types of consumers focus on price. The monopolist will therefore under-provide quality for both types compared to the quality he would offer to consumers with standard preferences. Given the definition of salience of Bordalo et al. (2013b) and linear preferences, it is impossible for the monopolist to make consumer types focus on different attributes. In contrast to that, Dahremöller and Fels (2015) assume that higher weight is given to attributes which have a high difference between highest and lowest type-specific value. This makes it possible that different types focus on different attributes.

Kőszegi and Szeidl (2013) develop a model with focus-weighted utility. Consumers focus and thus give more weight to attributes which have a greater range of consumption utility. The range is defined by the difference of the maximal and the minimal utility which an attribute in the choice set yields. Compared to Dahremöller and Fels (2015), the attention a consumer allocates to an attribute is independent of other attributes' characteristics. Wisson (2015) applies that model of focusing to the monopolist's problem. He finds that if focusing is strong enough, it widens the valuation gap between consumers. In equilibrium, the high type focuses on quality whereas the low type focuses on price. Incentive compatibility constraints do not bind in that case. The monopolist can offer the efficient product to high types and extract almost all surplus, while still serving the low types. In contrast to the case with standard preferences, separation now always dominates only serving high types and pooling is optimal in some situations. An additional insight of Wisson (2015) is that the monopolist does not benefit from offering a decoy in most cases. The difficulty not to make the decoy more desirable than the other products restricts the increase in profits. Again the predictions differ from my result that the monopolist separates with products which make price salient. Making quality salient for one type and price salient for the other type makes it easier to separate and increases profits. However, one of my results says that the monopolist would optimally want both types of consumers to focus on quality since this increases the willingness to pay. He would thus always try to offer decoys which implement this pattern of attention.

In the previous models by Dahremöller and Fels (2015), Kőszegi and Szeidl (2013) and Wisson (2015), the salience of attributes depends on the products in the choice set. The monopolist can influence salience by designing these products. In contrast, Zhou (2008) assumes that salience can directly be influenced by the monopolist. The monopolist can use advertising to draw attention towards some of the product's attributes.

This paper is related to a broader literature on monopolistic pricing in the presence of consumers with non-standard preferences. Carbajal and Ely (2012), Heidhues and Kőszegi (2004), Herweg and Mierendorff (2013), Hahn et al. (2018) and Karle and Möller (2017) consider a monopolist facing loss averse consumers. Hahn et al. (2018) find that loss aversion can explain why we observe pooling more often than expected. Similar to our model, price discrimination comes at a cost. Courty and Nasiry (2016) show how loss aversion can explain uniform/compressed pricing of different quality levels. Allowing the monopolist to offer decoys, our model predicts that he has an incentive to reduce price variance in order to make quality salient. Rotemberg (2011) finds the optimal products for fair consumers and DellaVigna and Malmendier (2004) let consumers discount hyperbolically. Esteban et al. (2007)'s consumers have self-control preferences in the sense of Gul and Pesendorfer (2001). Grubb (2009) lets his monopolist sell to overconfident consumers.

Salient thinking in the sense of Bordalo et al. (2013b) has been considered in other settings as e.g. competitive markets (Bordalo et al. 2016, Herweg et al. 2017) and asset markets (Bordalo et al., 2013a) or combined with limited attention (Inderst and Obradovits, 2015) and attribute shrouding (Inderst and Obradovits, 2016). Herweg et al. 2017 look at heterogeneous consumers in a setting with a brand manufacturer and a competitive fringe and show that the manufacturer benefits from introducing a decoy.

Alternative models of salience are developed e.g. by Kőszegi and Szeidl

(2013), Loomes and Sugden (1982) and Gabaix and Laibson (2006).

2.2.3 Empirical evidence

The salience-driven preferences of Bordalo et al. (2013b) provide an explanation to several observations which are hard to explain by standard preferences. Some evidence on context effects and salience-driven preferences has been mentioned in the introduction. Additional evidence on context effects is provided for example by Thaler (1985). He finds that the willingness to pay for a bottle of beer depends on the shop in which the consumer buys it. Hastings and Shapiro (2013) report that when the price of gasoline increased, surprisingly many consumers switched to cheaper low-quality gasoline. Evidence that individuals focus on salient characteristics is shown e.g. by Barber and Odean (2008). They find that investors simplify a decision by choosing the salient option. A lot of research in political science has been done on the choice of candidates on a ballot. Ho and Imai (2008) find that being the first, and thus salient, candidate on the list improves the chances to be chosen. Chetty et al. (2009) show that consumers react more strongly to tax changes if taxes are salient. Finally, Dertwinkel-Kalt et al. (2017) find strong support for the implications of salience-driven preferences in a laboratory experiment.

It is difficult to find evidence on products which are offered only in order to manipulate the consumer choices since firms are usually reluctant to reveal their strategies. However, some evidence suggests that they actually do offer such decoys. Ariely (2008) runs an experiment in which he tests the offer of The Economist. He finds that the introduction of a third, dominated option increases the share of consumers choosing the expensive offer. Vikander (2010) considers Audi advertising a premium car in halftime of super bowl as an example of a firm offering a high-quality product at a high price to consumers who are not supposed to buy it. Eliaz and Spiegler (2011) explain that Apple concentrates the advertisement for its MacBook Air on the extreme feature of being very thin. This attracts consumers into the store where they learn that the MacBook Air has, for example, no DVD drive. Eliaz and Spiegler (2011) interpret the healthy food at McDonald's as a strategy to attract consumers with a healthy image, without the intention to sell it. These decoy products have in common that they are rather bad deals in the sense of a low quality-price ratio. While most of them are high-quality products which are offered at a high price, also low-quality products can serve as decoys. Heath and Chatterjee (1995) report a meta-analysis of evidence for the effect of low-quality decoys. Jahedi (2011) conducts lab experiments to show how bargains influence consumers' decisions. He finds evidence that participants rather buy a product if it is presented next to a less attractive offer. Facing consumers with salience-driven preferences, I find that the monopolist offers low-quality decoys whenever he wants to pool or to exclude the low types. Thereby, he can attract consumer attention towards quality.

2.3 Model

Following the seminal model by Mussa and Rosen (1978), consider a monopolist facing consumers with different valuations of quality.

There is a continuum of consumers. A share $\alpha \in (0,1)$ is of type H and a share $(1-\alpha)$ is of type L. Consumer i's experience utility from consuming a product with quality q and price p is given by quasi-linear preferences for $i = L, H$:

$$u_i(q,p) = \theta_i q - p, \tag{1}$$

where θ_i denotes the valuation of quality. The two types of consumers value quality differently with $\theta_H = 1$ and $\theta_L = \theta < 1$. With such preferences, the difference in types can be interpreted as difference in income and higher income increases the demand.[1]

[1] I will show in Section 2.6.3 that the results hold for any quasi-linear utility function $u(q,\theta_i) - p$, with $u(q,\theta_i)$ increasing and concave in q, increasing in θ_i and satisfying the single-crossing property (a type with higher valuation has a higher marginal utility of quality).

The monopolist offers products with quality q and price p. The production technology exhibits constant returns to scale and production costs are increasing in quality at an increasing rate. For simplicity, assume that costs take the form $c(q) = \frac{1}{2}q^2$.[2] The monopolist's problem is to offer a product portfolio that maximizes his profit. Since the monopolist cannot observe the type of the consumer, he offers the same product portfolio to all consumers. Consumers observe all products that are offered. Since in Mussa and Rosen (1978) it is optimal for the monopolist to offer at most two products, I start with the assumption that the monopolist is restricted to two products. This restriction can be justified by high and increasing development costs. While the development costs of a second product can be covered by the additional profit, the development costs of a third product are for now assumed to be too high. Alternatively, one can think of products, where only two versions are possible. For example, there is typically only a first and a second class in the train. Books are offered with paperback or with hardcover. Food products have a standard and an organic version. In Section 2.6, I consider the monopolist's problem when he could offer three or more products.

Following Bordalo et al. (2013b), consumers have salience-driven preferences. If one attribute is more salient than the other, consumers give more weight to that attribute. Their decision utility $u^d(q, p)$ therefore differs from their experience utility. If quality is salient, price gets lower weight, characterized by the salience parameter $\delta \in (0, 1]$. If price is salient, quality gets lower weight δ. A consumer of type $i = H, L$ thus considers the following decision utility[3]:

$$u_i^d(q,p) \quad = \quad \begin{cases} \theta_i q - \delta p & \text{if quality is salient} \\ \delta\theta_i q - p & \text{if price is salient} \\ \theta_i q - p & \text{if price and quality are equally salient.} \end{cases} \tag{2}$$

Which attribute gets more attention is not chosen by the consumer but is endogenously determined by the monopolist's choice of offered products. The

[2] In Section 2.6.4, I generalize the main results to any increasing, strictly convex cost function, i.e. any $c(q)$ with $c'(q) > 0$, $c''(q) > 0$ and $c(0) = 0$.

[3] For simplicity, I use the same utility function as Bordalo et al. (2016).

salience of an attribute a depends on its distance to this attribute's value of a reference product. The reference product is defined by the average values of each attribute $\bar{a} = \frac{1}{N}\sum_j a_j$, where N is the number of products $(j = 1, .., N)$ in the consideration set. I assume that the consideration set consists of the products offered by the monopolist. Nevertheless, the consumer can always decide not to buy.[4] The salience of an attribute a is then given by the symmetric and continuous salience function $\sigma(a, \bar{a})$. There are two important assumptions on this salience function: ordering and homogeneity of degree zero. Ordering means that a higher distance from an attribute to its average leads to a higher value of the salience function:

Assumption 1 (Ordering)**.** *Let* $\mu = sgn(a_j - \bar{a})$*. Then for any* $\epsilon, \epsilon' \geq 0$ *with* $\epsilon + \epsilon' > 0$*, we have*

$$\sigma(a_j + \mu\epsilon, \bar{a} - \mu\epsilon') > \sigma(a_j, \bar{a}). \tag{3}$$

Intuitively, higher differences attract the attention more strongly. The second assumption captures the idea that the salience of an attribute is independent of its unit of measurement:

Assumption 2 (Homogeneity of degree zero)**.**

$$\sigma(\alpha a_j, \alpha\bar{a}) = \sigma(a_j, \bar{a}) \quad \textit{for all} \quad \alpha > 0. \tag{4}$$

Assuming that the salience function is homogeneous of degree zero and satisfies ordering implies diminishing sensitivity for positive attribute levels. The same distance to the average leads to a lower salience at higher levels of a and $\bar{a}$:

Diminishing sensitivity: For any $a_j, \bar{a} \geq 0$ and all $\epsilon > 0$, we have

$$\sigma(a_j + \epsilon, \bar{a} + \epsilon) > \sigma(a_j, \bar{a}). \tag{5}$$

Diminishing sensitivity incorporates Weber's law into the salience function. Weber's law says that the perceived change in stimuli gets smaller at higher initial levels of the stimuli.

[4]This assumption differs from the assumption of Bordalo et al. (2013b). They consider the outside option to be part of the consideration set.

Considering only two attributes, quality and price, quality is salient for a product j and a consumer i if and only if the salience function is higher for quality than for price:

$$\sigma(\theta_i q_j, \theta_i \bar{q}) > \sigma(p_j, \bar{p}). \tag{6}$$

Price is salient if and only if $\sigma(\theta_i q_j, \theta_i \bar{q}) < \sigma(p_j, \bar{p})$ and price and quality are equally salient if and only if $\sigma(\theta_i q_j, \theta_i \bar{q}) = \sigma(p_j, \bar{p})$. In contrast to Bordalo et al. (2013b), consumers are heterogeneous in their valuation of quality. It is assumed that the salience of quality is defined by the subjective utility from quality $\theta_i q$ and not by objective quality q. However, it follows directly from the assumption of homogeneity of degree zero and the linearity of preferences that the value of the salience function is independent of the type of a consumer:

$$\sigma(\theta_i a_j, \theta_i \bar{a}) = \sigma(a_j, \bar{a}) \text{ for all } \theta_i > 0. \tag{7}$$

Whether a product's price or a product's quality is salient does therefore not depend on the type of the consumer. The same attribute is salient for all types and which attribute is salient thus constitutes a feature of the market under consideration.[5]

We can use Proposition 1 from Bordalo et al. (2013b) in order to determine which attribute is salient. Homogeneity of degree zero of the salience function implies that the salience of attributes is determined by the quality-price ratio of a product. Given a product (q_j, p_j) is neither dominated nor dominates the reference product $(\bar{q}, \bar{p})$, i.e. $(q_j - \bar{q})(p_j - \bar{p}) > 0$, then the advantage of that product (higher quality or lower price) is salient if and only if

$$\frac{q_j}{p_j} > \frac{\bar{q}}{\bar{p}}. \tag{8}$$

In the case of two products (q_H, p_H) and (q_L, p_L) with $q_H > q_L$ and $p_H > p_L$, the Proposition implies that quality is salient for both products if

[5]This result relies on preferences being linear in the taste parameter θ. Hence, it also holds for experience utility given by $\theta_i u(q) - p$. If experience utility is equal to $u(q, \theta_i) - p$, different types might focus on different attributes.

and only if

$$\frac{q_H}{p_H} > \frac{q_L}{p_L}, \tag{9}$$

whereas price is salient when the inequality is reversed. Quality is salient if and only if the quality-price ratio of the high-quality product is higher than the quality-price ratio of the low-quality product.

Without taking into account salient thinking, the monopolist will separate by offering the high-quality product at a higher price per quality. Price will then be salient, which reduces the willingness to pay of the consumers and might thus not be in the best interest of the monopolist. In the next section, I will derive this benchmark result when consumers have standard preferences.

2.4 Benchmark with standard preferences

The monopolist can offer two different products and induce types to separate or he can pool by selling the same product to both types. As a third option, he can exclude the low type from the market by offering a product(s) that only the high type is willing to buy. In this section, I will review the results from the model of Mussa and Rosen (1978) with two types of consumers and use it as a benchmark. In the following section, the optimal product portfolio for consumers with salience-driven preferences is determined in order to compare it with the benchmark.

If the monopolist wants to separate the two types, he has to take into account the participation constraints (PC) and the incentive compatibility constraints (IC). The monopolist's problem is

$$\begin{aligned}
\max_{p_H, p_L, q_H, q_L} \quad & \alpha(p_H - \frac{1}{2}q_H^2) + (1-\alpha)(p_L - \frac{1}{2}q_L^2) & \\
\text{s.t.} \quad & \theta q_L - p_L \geq 0 & PC_L \\
& q_H - p_H \geq 0 & PC_H \\
& \theta q_L - p_L \geq \theta q_H - p_H & IC_L \\
& q_H - p_H \geq q_L - p_L. & IC_H
\end{aligned}$$

It is well known that the participation constraint of the low type and the incentive compatibility constraint of the high type will be binding. The other two constraints are then redundant. The optimal products satisfy the first order conditions: $q_H^B = 1$ and $q_L^B = \theta - \frac{\alpha}{1-\alpha}(1-\theta)$. Profits from separation are $\pi_S^B = \frac{1}{2}\frac{1}{1-\alpha}(\theta^2 + \alpha - 2\alpha\theta)$, where I use the superscript B to denote the benchmark.

Such separation is possible only for $\theta \geq \alpha$ since the quality offered to low types must be non-negative. If the valuation of the low type is lower, the monopolist benefits from excluding the low type from the market and designing a product for high types only. The participation constraint of the high type is then binding. The following first order condition gives us the optimal product: $q_E^B = 1$. The monopolist's profits from exclusion are $\pi_E^B = \frac{1}{2}\alpha$.

If the monopolist decides to sell the same product to both types of consumers, the participation constraint of the low type is binding. The optimal pooling product is characterized by the first order condition: $q_P^B = \theta$. The monopolist's profits amount to $\pi_P^B = \frac{1}{2}\theta^2$.

Comparing the profits from the different strategies identifies the optimal strategy of the monopolist. I assume that the monopolist always separates when he is indifferent. The monopolist prefers separation to exclusion if and only if

$$\pi_S^B \geq \pi_E^B \Leftrightarrow (\theta - \alpha)^2 \geq 0. \tag{10}$$

The monopolist prefers separation to pooling if and only if

$$\pi_S^B \geq \pi_P^B \Leftrightarrow (1 - \theta)^2 \geq 0. \tag{11}$$

Both conditions are always fulfilled, so whenever separation is possible it is optimal for the monopolist. Finally, exclusion is preferred to pooling if and only if

$$\pi_E^B \geq \pi_P^B \Leftrightarrow \theta \leq \alpha^{1/2}. \tag{12}$$

In case of quadratic costs and consumers with standard preferences, the monopolist's optimal strategy is to separate if $\theta \geq \alpha$, and to exclude low types otherwise. The monopolist's optimal strategy is thus to always differentiate the consumers' types. Proposition 1 summarizes these results:

Proposition 2.1. *Given standard preferences, the optimal strategy of the monopolist can be characterized as follows:*

1. **Separation**: *If $\theta \geq \alpha$, the monopolist separates with $q_H^B = 1$ and $p_H^B = \frac{1}{1-\alpha}[1+\theta^2-(1+\alpha)\theta]$, $q_L^B = \theta - \frac{\alpha}{1-\alpha}(1-\theta)$ and $p_L^B = \theta^2 - \frac{\alpha}{1-\alpha}\theta(1-\theta)$.*

2. **Exclusion**: *If $\theta < \alpha$, the monopolist only serves high types with $q_E^B = 1$ and $p_E^B = 1$.*

If the valuation of the low types is high enough, it is optimal for the monopolist to sell to both types and design the products such that high and low types separate. The high type is offered the efficient quality while the low type's quality is distorted downwards to make sure the high type does not deviate to the low-quality product. If the valuation of quality of the low type is low, the monopolist does better by excluding low types and extracting the whole rent from high types. The monopolist still offers the efficient quality to high types, but can now ask for a higher price for the high-quality product.

2.5 Salience-driven consumer preferences

When consumers exhibit salience-driven preferences, the monopolist has to take into account how the design of his product portfolio affects the salience of the products' attributes. Participation and incentive compatibility constraints of the consumers depend on whether quality or price (or neither) is salient. The monopolist can again choose between separation, exclusion and pooling the two types of consumers. Considering these strategies separately, it turns out that there are direct relationships between the strategies and the salience of attributes. In the following subsections, these relationships between strategies and salience, the profits and the optimal products are derived.

2.5.1 Separation with quality salience

If consumers have salience-driven preferences, it seems intuitive that letting the two types focus on different attributes would make separation easier. However, we already found that it is impossible to design two products which make one type of consumer focus on quality and the other type focus on price. The monopolist can only "choose", by designing the products accordingly, whether consumers focus on quality or on price (or on neither). The consumers' willingness to pay is higher if quality is salient because it makes them discount, in relative terms, the payment they have to make. It therefore seems promising for the monopolist to make quality salient. In order to make quality salient, he has to design his products such that the high-quality version has a higher quality-price ratio:

$$\frac{q_H}{p_H} > \frac{q_L}{p_L}. \tag{13}$$

However, independent of the weight a consumer attaches to quality and price, the following holds: any two products which satisfy condition (13) cannot satisfy simultaneously the participation constraint and the incentive compatibility constraint of the low type. Making quality salient requires offering the higher quality at a lower price per quality. Since preferences are linear, a product with higher quality offered at a lower price per quality would be strictly preferred by the low type. Figure 2.1 shows that given a low-quality product (q_L, p_L) which the low type would accept, any higher quality product which makes quality salient is strictly preferred by the low type.

Lemma 2.1. *Suppose there is a product (q_L, p_L) which satisfies the participation constraint of a consumer with utility $u(q,p) = \theta q - \delta p$, $\delta \in (0,1]$. Then, any product (q_H, p_H) with higher quality $q_H \geq q_L$ and higher price $p_H \geq p_L$ which makes quality salient, i.e. $\frac{q_H}{p_H} > \frac{q_L}{p_L}$, is strictly preferred to (q_L, p_L).*

Lemma 2.1 implies that it is impossible for the monopolist to separate consumers who focus on quality with two products which indeed make quality salient. The same is true if consumers are focusing on price or on neither

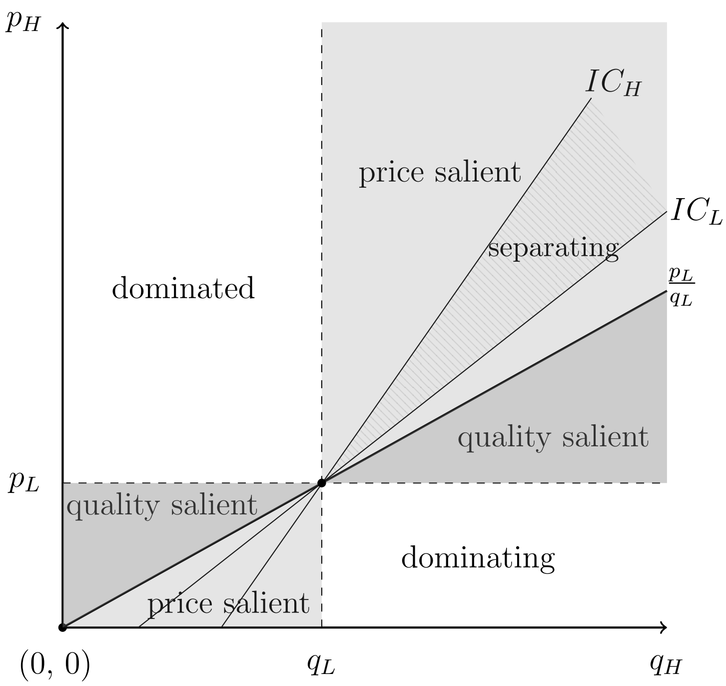

Figure 2.1: **Separating consumers with salience-driven preferences.** If the participation constraint of the low type is satisfied, the incentive compatibility constraint of the low type is steeper than the constant ratio line p_L/q_L. Then, any product which would separate the two types needs to have a higher price-quality ratio than product L and hence would make price salient.

of the attributes. Hence, the monopolist cannot separate consumers with two products which make quality salient. The proof can be found in the Appendix.

2.5.2 Separation with price salience

The analysis in the previous section has shown that the monopolist is not able to separate consumers with products which make quality salient. Furthermore, I show in the Appendix that the monopolist would never separate with products which induce neutral salience. It remains to check whether the monopolist can and wants to separate consumers while making price salient. Price is salient if and only if the quality-price ratio of the low-quality product is higher than the quality-price ratio of the high-quality product. Figure 2.1 shows that any higher quality product which satisfies the conditions for separation lies in the area of price salience, given the incentive compatibility constraint of the low type is not binding. Therefore, any separating products will induce price salience. In order to find the optimal products for the monopolist, we have to solve the profit maximization problem of the monopolist given price salience. The monopolist faces the participation and incentive compatibility constraints of consumers who give a higher weight to prices:

$$\begin{aligned} &\delta\theta q_L - p_L \geq 0 && PC_{LP} \\ &\delta q_H - p_H \geq 0 && PC_{HP} \\ &\delta\theta q_L - p_L \geq \delta\theta q_H - p_H && IC_{LP} \\ &\delta q_H - p_H \geq \delta q_L - p_L. && IC_{HP} \end{aligned}$$

Redefining types as $\theta'_L = \delta\theta$ and $\theta'_H = \delta$, it is clear that the problem can be solved in the standard way. In the optimum, the participation constraint of the low type and the incentive compatibility constraint of the high type are binding: $p_L = \delta\theta q_L$ and $p_H = \delta(q_H - q_L) + \delta\theta q_L$. The participation constraint of the high type and the incentive compatibility constraint of the low type are then redundant. The monopolist maximizes his profits:

$$\max_{q_H, q_L} \ \alpha[\delta(q_H - q_L) + \delta\theta q_L - \frac{1}{2}q_H^2] + (1-\alpha)[\delta\theta q_L - \frac{1}{2}q_L^2]. \tag{14}$$

The first order conditions define the optimal qualities. The optimal prices are then determined by the binding participation constraint of the low type and the binding incentive compatibility constraint of the high type:

$$q_H = \delta, \tag{15}$$

$$q_L = \delta\theta - \frac{\alpha}{1-\alpha}\delta(1-\theta), \tag{16}$$

$$p_H = \delta^2 \frac{1}{1-\alpha}[1 + \theta^2 - (1+\alpha)\theta], \tag{17}$$

$$p_L = \delta^2\theta^2 - \frac{\alpha}{1-\alpha}\delta^2\theta(1-\theta). \tag{18}$$

The optimal separating products given price salience indeed satisfy the price salience condition:

$$\frac{q_H}{p_H} < \frac{q_L}{p_L} \Leftrightarrow 0 < \frac{(1-\theta)^2}{\delta\theta[1-\theta+\theta(\theta-\alpha)]}. \tag{19}$$

The condition $\theta \geq \alpha$ is again necessary for separation to exist and be possibly optimal because first, the monopolist cannot offer products with negative quality and second he would make zero profit on low types if $\theta < \alpha$ and then prefers to exclude them (see Section 2.5.3).

Similar to the benchmark case with standard preferences, there is no distortion at the top given price salience. The low quality is distorted downwards relative to the efficient price-salient quality in order to discourage the high types from deviating. When interpreting the "no distortion at the top" result as quality being the same as when the consumer type was alone in the market, the results change compared to the benchmark case. I show in Section 2.5.3 that if the high type was alone in the market, the monopolist would be able to make quality salient and would offer a higher quality in order to benefit from the high willingness to pay. The presence of the low type makes price salience necessary and reduces the quality offered to the high type.

Compared to the benchmark case, the willingness to pay of consumers who focus on price is lower. The quality offered to consumers with salience-driven preferences is therefore lower, discounted by the salience parameter δ. The monopolist's profit from separating consumers is then:

$$\pi_S = \delta^2 \frac{1}{2} \frac{1}{1-\alpha}(\theta^2 + \alpha - 2\alpha\theta). \tag{20}$$

If salience becomes more important, i.e. if δ decreases, profits decrease.

Taking into account the salience of the consumers, it turns out that a monopolist cannot separate with quality salience and separating with neutral salience is never optimal. The monopolist only separates with products that make price salient.

Proposition 2.2. *If it is optimal for a monopolist to separate consumers, he separates by use of a product portfolio which makes price salient.*

Proposition 2.2 shows that if consumers have salience-driven preferences, separation comes at a cost. In order to separate, the monopolist uses a product portfolio which makes price salient and decreases the willingness to pay of the consumers. This has a negative effect on his profits from separation.

2.5.3 Exclusion

If the monopolist excludes the low types, he offers a product (q_E, p_E) which satisfies the participation constraint of the high types but not of the low types. The willingness to pay for the product of the high type is highest when its quality is salient. Therefore, the monopolist could benefit from offering a second product (q_D, p_D) which makes quality salient. This second product is offered as a decoy, in the sense that it draws consumers' attention towards quality but is not meant to be sold. Hence, the decoy must be designed such that quality becomes salient and both types do not choose to buy it. Given the exclusion product (q_E, p_E) satisfies the participation constraint of the high type, Lemma 2.1 (with $\theta = 1$) implies that it is impossible to use a higher quality product as a decoy. Any higher quality product which makes quality salient would be preferred by the high type. In contrast to that, Lemma 2.2 below shows that any lower quality product with $q_D < q_E$ and $p_D < p_E$ which makes quality salient would not be preferred by the high type.

Lemma 2.2. *Suppose there is a product (q_E, p_E) which satisfies the participation constraint of a consumer with utility $u(q,p) = q - \delta p$, $\delta \in (0,1]$. Then, any product (q_D, p_D) with lower quality $q_D \leq q_E$ and lower price $p_D \leq p_E$ which makes quality salient, i.e. $\frac{q_D}{p_D} < \frac{q_E}{p_E}$, is strictly dominated by (q_E, p_E).*

The proof of Lemma 2.2 can be found in the Appendix. In order to make sure that the low type does not buy the decoy, his participation constraint must be taken into account. The exclusion product does not satisfy the participation constraint of the low type: $\frac{q_E}{p_E} < \theta$. Any lower quality product which makes quality salient does not satisfy the participation constraint either, since $\frac{q_D}{p_D} < \frac{q_E}{p_E} \Rightarrow \frac{q_D}{p_D} < \theta$.

All products in the shaded area in Figure 2.2 satisfy the conditions for a decoy, i.e. $\frac{q_D}{p_D} < \frac{q_E}{p_E}$, $q_D < q_E$ and $p_D < p_E$. Such an area always exists. Consider e.g. a product $(x, p_E - \epsilon)$ with $0 < x < q_E$. There always exists a sufficiently small $\epsilon > 0$ such that $\epsilon < \frac{p_E}{q_E}(q_E - x)$, which implies quality salience.

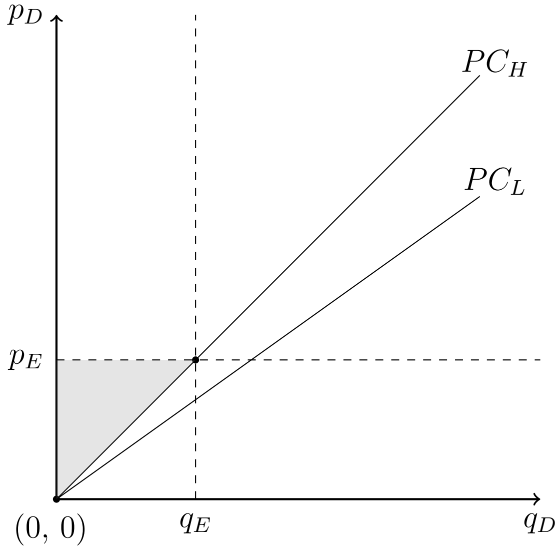

Figure 2.2: **Possible decoys given exclusion product (q_E, p_E).** For any product E which makes the participation constraint of the high type binding, there exists an area (gray) with products that have a lower price, a lower quality and a lower quality-price ratio than product E. The lower quality and the lower quality-price ratio imply that neither of the consumer types would prefer a product in that area.

If the exclusion product (q_E, p_E) satisfies the participation constraint of the high type, the monopolist always finds a low-quality decoy that makes quality salient. He can thus choose the exclusion product in order to maximize his profits, only considering the participation constraint of the high type given quality is salient. The participation constraint of the high type will be binding $p_E = \frac{1}{\delta} q_E$. The monopolist maximizes his profit:

$$\max_{q_E} \ \frac{1}{\delta} q_E - \frac{1}{2} q_E^2. \tag{21}$$

The optimal quality is defined by the first order condition and the optimal price is determined by the binding participation constraint of the high type:

$$q_E = \frac{1}{\delta}, \qquad p_E = \frac{1}{\delta^2}. \tag{22}$$

The monopolist will offer the efficient quality for high types who focus on quality. The monopolist's profit from exclusion is

$$\pi_E = \frac{1}{\delta^2} \frac{1}{2} \alpha. \tag{23}$$

If salience becomes more important, consumers give a higher relative weight to quality in case of quality salience. The monopolist's profit from exclusion increases.

Proposition 2.3. *The monopolist always excludes low types by use of a product portfolio that makes quality salient.*

If consumers have salience-driven preferences, the monopolist can increase the consumers' willingness to pay by excluding low types and making quality salient. Exclusion thus entails the advantage of making quality salient. The decoy which is offered together with the exclusion product needs to have the following characteristics:

$$0 \leq q_D < \frac{1}{\delta}, \qquad \frac{1}{\delta} q_D < p_D < \frac{1}{\delta^2}. \tag{24}$$

As it is typical for decoys, it is a "bad deal", i.e. it has a lower quality-price ratio than the product which is meant to be sold.

2.5.4 Pooling

If the monopolist pools the two types, he would again want to offer an additional product (q_D, p_D) as a decoy to make quality salient. Since the pooling product satisfies the participation constraint of both consumer types, Lemma 2.1 and Lemma 2.2 can be applied for both consumer types. Given the pooling product (q_P, p_P), Lemma 2.1 implies that all high-quality products that make quality salient would be preferred by both types and hence cannot be used as a decoy. Lemma 2.2, in contrast, says that any lower quality product with $q_D < q_P$ and $p_D < p_P$ which makes quality salient is not preferred by consumers. Thus it is sufficient to show that there always exists a lower quality product which makes quality salient. Given (q_P, p_P), all products in the shaded area in Figure 2.3 are of lower quality and have a lower quality-price ratio. They can thus be used as decoys.

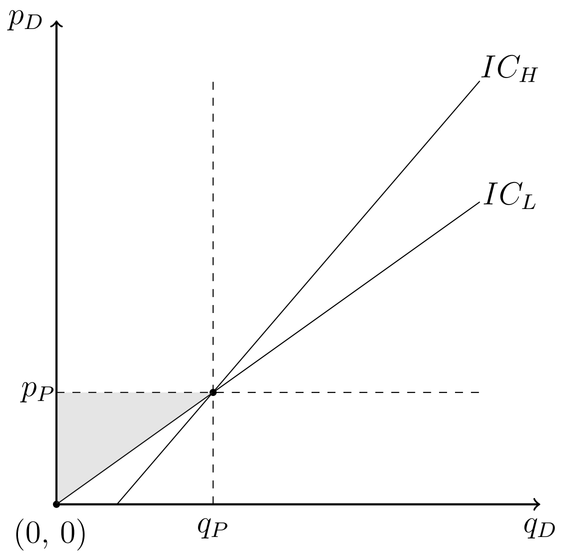

Figure 2.3: **Possible decoys given pooling product (q_P, p_P).** For any product P which would pool the two types, there exists an area (gray) with products that have a lower price, a lower quality and a lower quality-price ratio than product P. The lower quality and the lower quality-price ratio imply that neither of the consumer types would prefer a product in that area.

Again, such an area always exists. Consider e.g. a product $(x, p_P - \epsilon)$ with $0 < x < q_P$. There always exists an $\epsilon > 0$ such that $\epsilon q_P < p_P(q_P - x)$, which implies quality salience.

It is always possible to find a decoy that makes quality salient when pooling. Therefore, the monopolist can choose the pooling product only considering the participation constraints of both types given quality is salient.

The participation constraint of the low type is more restrictive and will thus be binding $p_P = \frac{1}{\delta}\theta q_P$. The monopolist maximizes his profit:

$$\max_{q_P} \ \frac{1}{\delta}\theta q_P - \frac{1}{2}q_P^2. \tag{25}$$

The first order condition and the binding participation constraint of the low type determine the optimal product:

$$q_P = \frac{1}{\delta}\theta, \qquad\qquad p_P = \frac{1}{\delta^2}\theta^2. \tag{26}$$

The monopolist will offer the efficient quality for low types who focus on quality. Consumers' willingness to pay is higher if they overvalue quality. Quality and price are therefore higher than in the case of consumers with standard preferences. The monopolist's profits from pooling amount to

$$\pi_P = \frac{1}{2}\frac{1}{\delta^2}\theta^2. \tag{27}$$

A stronger distortion of weights compared to the benchmark case imply that consumers have a higher willingness to pay in case of quality salience. The monopolist's profit from pooling increases in the strength of salience.

Proposition 2.4. *The monopolist always pools by use of a product portfolio that makes quality salient.*

Salient thinking of consumers enables the monopolist to increase their willingness to pay. In the same way as exclusion, pooling thus comes at the benefit of making quality salient. Given the pooling product, the monopolist offers a decoy with:

$$0 \leq q_D < \frac{1}{\delta}\theta, \qquad\qquad \frac{1}{\delta}\theta q_D < p_D < \frac{1}{\delta^2}\theta^2. \tag{28}$$

In the case of pooling and of exclusion, the monopolist benefits from offering a second product with lower quality and lower price. Since the exclusion product has higher quality and price than the pooling product, the decoy can also have higher attribute values in this case. Decoys are used to make quality salient and therefore only appear if they successfully do so. There are no decoys when we observe price salience.

2.5.5 Optimal strategy

In the last subsections, I derived the monopolist's strategies and the profits he can achieve by applying them. The monopolist can choose to separate by use of a product portfolio which makes price salient. Alternatively, he can exclude the low types or pool both types by use of product portfolios which make quality salient. The monopolist's profits given each strategy are:

$$\text{Separation: } \pi_S = \frac{1}{2}\frac{1}{1-\alpha}\delta^2(\theta^2+\alpha-2\alpha\theta) \tag{29}$$

$$\text{Exclusion: } \pi_E = \frac{1}{2}\frac{1}{\delta^2}\alpha \tag{30}$$

$$\text{Pooling: } \pi_P = \frac{1}{2}\frac{1}{\delta^2}\theta^2. \tag{31}$$

In order to find the optimal strategy given the valuation θ and the share of high types α, the monopolist compares these profits. When the monopolist decides between separation with price salience and pooling with quality salience, he prefers separation if and only if the relative valuation of low types is low enough:

$$\pi_S \geq \pi_P \Leftrightarrow \theta \leq \frac{\delta^2\sqrt{\alpha^2\delta^4+\alpha(1-\alpha-\delta^4)}-\alpha\delta^4}{1-\alpha-\delta^4} \equiv \hat{\theta}_1(\alpha). \tag{32}$$

The difference $\pi_S - \pi_P$ is decreasing in θ. Hence, it is positive if and only if θ is not too high. In the benchmark case, separation was always preferred to pooling. However, in the presence of salient thinking, separation requires consumers to focus on price which reduces the profit. In contrast to that, the profit from pooling increases since quality is salient which makes consumers willing to pay more. Therefore, there is now a range of high valuations for which pooling is the optimal strategy when consumers exhibit salience-driven preferences.

Comparing the profits from pooling and exclusion, the monopolist prefers to exclude if and only if the valuation of the low type is not too high:

$$\pi_E \geq \pi_P \Leftrightarrow \theta \leq \alpha^{1/2} \equiv \hat{\theta}_2(\alpha). \tag{33}$$

Salient thinking of consumers does not change the payoff-comparison between pooling and excluding. Both strategies make quality salient which increases profits by the same factor.

Finally, the difference $\pi_S - \pi_E$ increases in θ whenever $\alpha \leq \theta$, i.e. whenever separation is possible. Hence, there is a third threshold for the valuation of the low type $\hat{\theta}_3(\alpha)$:

$$\pi_S \geq \pi_E \Leftrightarrow \theta \geq \alpha + \alpha^{1/2}(1-\alpha)^{1/2}\left(\frac{1}{\delta^4} - 1\right)^{1/2} \equiv \hat{\theta}_3(\alpha). \qquad (34)$$

For valuations above this threshold, separation is preferred to exclusion. Given salient thinking of consumers, the profits from exclusion increase if δ decreases, while the profits from separation decrease. It is thus less likely than in the benchmark case that the monopolist prefers separation, i.e. $\hat{\theta}_3(\alpha) \geq \alpha$.

Proposition 2.5 uses the three thresholds and provides a formal description of the monopolist's optimal strategy:

Proposition 2.5. *The optimal strategy of the monopolist given salience-driven preferences can be characterized as follows:*

1. **Separation***: If $\hat{\theta}_1 \geq \theta \geq \hat{\theta}_3$, the monopolist separates with products L and H: $q_H = \delta$ and $p_H = \delta^2 \frac{1}{1-\alpha}[1+\theta^2-(1+\alpha)\theta]$, $q_L = \delta\theta - \frac{\alpha}{1-\alpha}\delta(1-\theta)$ and $p_L = \delta^2\theta^2 - \frac{\alpha}{1-\alpha}\delta^2\theta(1-\theta)$. Price is salient for both products.*

2. **Exclusion***: If $\theta \leq \min[\hat{\theta}_2, \hat{\theta}_3]$, the monopolist only serves high types with product E: $q_E = \frac{1}{\delta}\alpha$ and $p_E = \frac{1}{\delta^2}\alpha$. He additionally offers a decoy D: $0 \leq q_D < \frac{1}{\delta}$ and $\frac{1}{\delta}q_D < p_D < \frac{1}{\delta^2}$. Quality is salient for both products.*

3. **Pooling***: If $\theta \geq \max[\hat{\theta}_1, \hat{\theta}_2]$, the monopolist serves both types of consumers with product P: $q_P = \frac{1}{\delta}\theta$ and $p_P = \frac{1}{\delta^2}\theta^2$. He additionally offers a decoy D: $0 \leq q_D < \frac{1}{\delta}\theta$ and $\frac{1}{\delta}\theta q_D < p_D < \frac{1}{\delta^2}\theta^2$. Quality is salient for both products.*

Figures 2.4 and 2.5 show the optimal strategy for varying shares of high types α and relative valuations θ. Consumers with standard preferences ($\delta = 1$) are separated if $\theta \geq \alpha$. In all other cases, the monopolist excludes the low types.

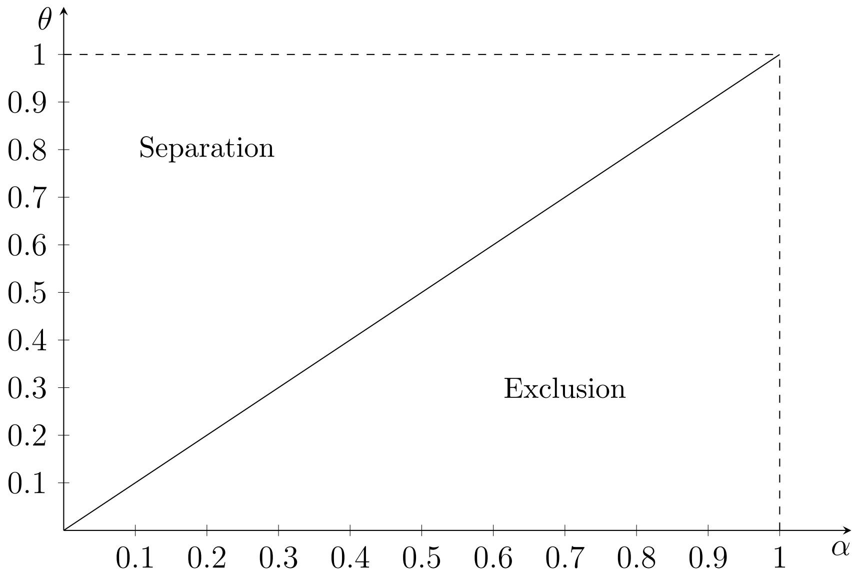

Figure 2.4: **Optimal strategy of monopolist if consumers have standard preferences, i.e. $\delta = 1$.** A monopolist maximizes profits by separating consumers if heterogeneity and the share of high types are low, and excluding low types otherwise.

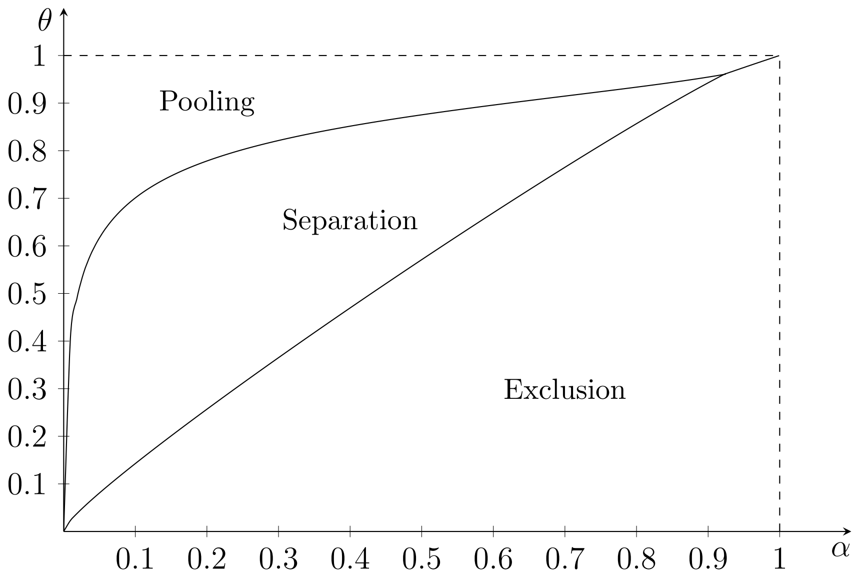

Figure 2.5: **Optimal strategy of monopolist if consumers have salience-driven preferences, i.e. $\delta < 1$.** A monopolist maximizes profits by pooling consumers if heterogeneity and the share of high types are low, and excluding low types if heterogeneity and the share of high types are high. Separation is optimal for an intermediate range of heterogeneity and share of high types.

If salience becomes stronger, i.e. δ decreases, the costs of price salience in the separation case become more severe, while the gains of quality salience with pooling and excluding increase. It follows that the monopolist will choose separation less often if consumers have salience-driven preferences.

If salience is strong enough $[\delta < \hat{\delta}(\alpha) \equiv 0.841(1+\alpha^{\frac{1}{2}})^{\frac{1}{4}}]$, separation is always dominated by exclusion or pooling. This follows from the fact that given $\delta < \hat{\delta}(\alpha)$, exclusion and pooling are preferred to separation at $\hat{\theta}_2$, i.e. where exclusion and pooling are equally beneficial. For $\theta < \hat{\theta}_2$, exclusion is preferred to separation because profits from separation decrease if θ decreases, while profits from exclusion remain constant. For $\theta > \hat{\theta}_2$, profits from pooling are higher that profits from separation since profits from pooling increase faster in θ. Hence, a range in which separation is optimal exists if and only if $\delta \geq \hat{\delta}(\alpha)$. While the monopolist never sells the same product to both types of consumers with standard preferences (i.e. he never pools), pooling is optimal given salience-driven consumer preferences if the valuation of the low type is high.

As shown earlier, both types of consumers focus on the same attribute. It is thus of interest how the characteristics of a market determine the attribute on which consumers focus.

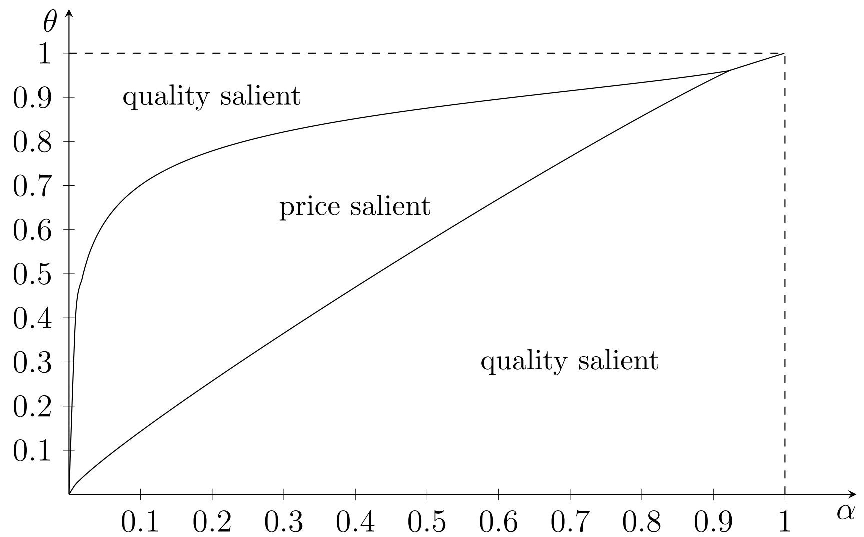

Figure 2.6: **Salience in a monopolistic market.** Price is salient in a market with intermediate heterogeneity and an intermediate share of high types.

Which attribute is salient relates directly to the strategy of the monopolist. Figure 2.6 shows which attribute is salient depending on the share of high types and the valuation of low types. Due to the direct relation between strategy and salience, Proposition 2.5 gives us some insights on when price salience can be observed:

Corollary 2.1. *Suppose that* $\delta \in (\hat{\delta}(\alpha), 1]$. *Whether we observe a quality- or a price-salient market depends on the distribution of types and their degree of heterogeneity. Quality is salient in markets with low heterogeneity and low share of high types and in markets with high heterogeneity and high share of high types. Price is salient in markets with intermediate heterogeneity and intermediate share of high types.*

If salience becomes stronger, the monopolist is more likely to induce quality salience. In a quality salient market, the consumers overestimate the value which the products will give to them. The monopolist benefits from this misperception and achieves higher profits. In a price salient market, the consumers underestimate the value of the products. The lower willingness to pay reduces the return on quality for the monopolist and induces him to provide lower quality.

The theory presented predicts that the monopolist will always offer two products. Whenever consumers focus on quality, the low-quality product is a decoy and not actually sold. The high-quality product is then a "better deal" in the sense that it is offered with a quality discount relative to the low-quality product. When consumers focus on price, the monopolist is separating the types and the high-quality product is a "bad deal", i.e. it is offered with a quality premium. The range for which separation with price salience and a quality premium is optimal becomes small if salience gains importance. As Maskin and Riley (1984), we can interpret quality as quantity. Salience-driven consumer preferences then provide an explanation for why quantity premia are rare in reality. Gerstner and Hess (1987) studied the pricing of a supermarket and found that only 1.7% of the packages were offered with a quantity premium. Kokovin et al. (2008) observe that some expensive liquor and expensive chocolate is offered with quantity premia. Verboven

(1999) claims that many products, e.g. cars and hotel rooms, are offered with extra options that seem to be overpriced. For these products, we would predict separation with price salience if the monopolist is restricted to only two variants.

The model also provides an explanation for the observation that, when several products are offered, the price often varies with quality less than expected (Orbach and Einav, 2007; Courty and Nasiry, 2016; Richardson and Stähler, 2016; DellaVigna and Gentzkow, 2017). A monopolist who faces consumers with salience-driven preferences has to take into account that a high price difference attracts consumers' attention towards the price. Whenever he pools or excludes the low types, he thus offers two products with a small price difference in order to make consumers focus on quality.

2.6 Robustness

So far, the analysis restricted attention to a monopolist who could not offer more than two products. Avoiding price salience in case of separation requires the development and introduction of at least one additional product. The optimal strategy of a monopolist thus depends on how costly it is to develop additional decoys. Without development costs, it turns out that it is always possible to make quality salient by offering enough decoys. Assuming that there are non-zero development costs, the result holds that the monopolist will be less likely to separate than when consumers had standard preferences.

In this section, I first assume that there are no development costs and allow for a third product. It turns out that there are situations in which the monopolist cannot find a third product that would make the optimally separating products quality salient. However, he can always offer a decoy that makes the high-quality product quality salient and the low-quality product price salient. Whenever separation is optimal, the monopolist benefits from using such a decoy. This suggests that whenever there is separation, there will be at least one decoy offered.

In a second step, I keep the assumption of no development cost but let the monopolist offer as many decoys as he wishes. I can show that it is then always possible to separate optimally with quality salience.

If there were some development costs per decoy, the monopolist would face a trade-off between the gain from more beneficial salience and the development costs. Thus, in a situation in which separation would be optimal, the predictions of the salience of attributes and of the number of decoys depends on development costs. If development costs are high, we expect to observe no decoys and price salience (and less separation than in the benchmark case). If development costs are low, the monopolist would offer decoys and a quality salient product portfolio. As in the case of two products, we would only observe decoys if quality is salient for at least one of the products that are sold. If price is salient for both products, the decoys were useless and should thus not be offered.

Finally, I show the robustness of the results of Section 2.5 for a general utility function and a general cost function.

2.6.1 Three products

The restriction that the monopolist can offer at most two products makes it impossible to separate the types and make quality salient at the same time. However, the monopolist might consider offering a third product as a decoy. With a decoy, the monopolist can influence the salience of the attributes while separating with two other products. Quality becomes salient if the decoy increases the variation in quality sufficiently.

I assume that it is impossible to offer a product with negative quality. It can then be shown that when offering the optimal separating products given quality salience (q_H^q, p_H^q) and (q_L^q, p_L^q), it is not always possible to find a decoy which induces such salience. Thus, the monopolist cannot always reach the optimal quality salience profit under separation. This suggests that there will be less separation in the case of salience-driven preferences compared to the benchmark even when a third product could be offered without development costs.

Proposition 2.6. *Given the optimal products for separation with quality salience, it is impossible for the monopolist to make quality salient with a single decoy with non-negative quality if* $\alpha > 2\theta - 1$ *and* $\theta < \delta^2$.

The lower bound on the share of high types is derived from the condition that the decoy must have non-negative quality. If the share of high types is high, the quality of product L is rather low and the decoy needs to have a very low quality in order to bring more variation in the quality dimension. The threshold is increasing in the valuation of the low type. A higher valuation increases the quality of the low type's product and makes it more likely to find a decoy with non-negative quality that increases quality variation sufficiently. Together with the condition $\theta < \delta^2$, the lower bound on α is sufficient to imply that all high-quality decoys would be preferred by the high type.

In order to derive the conditions on the share of high types and the low type's valuation, we first have to determine the optimal products given quality salience. The derivation is analogous to the case in which both products are price salient. The incentive compatibility constraints imply that $q_H \geq q_L$. The incentive compatibility constraint of the high type and the participation constraint of the low type are binding. This makes the incentive compatibility constraint of the low type and the participation constraint of the high type redundant. Hence, the optimal products given quality salience are:

$$q_H^q = \frac{1}{\delta}, \tag{35}$$

$$q_L^q = \frac{1}{\delta}\theta - \frac{1}{\delta}\frac{\alpha}{1-\alpha}(1-\theta), \tag{36}$$

$$p_H^q = \frac{1}{\delta^2}\frac{1}{1-\alpha}[1+\theta^2-(1+\alpha)\theta], \tag{37}$$

$$p_L^q = \frac{1}{\delta^2}\theta^2 - \frac{1}{\delta^2}\frac{\alpha}{1-\alpha}\theta(1-\theta). \tag{38}$$

I now derive the conditions on the share of high types and the low types valuation. Given the three products H, L and D, the average quality is $\bar{q} = \frac{q_H+q_L+q_D}{3}$ and the average price is $\bar{p} = \frac{p_H+p_L+p_D}{3}$. We can consider the quality-price space for the decoy D to determine its consequences on the salience of the attributes of products L and H. Proposition 1 of Bordalo et al. (2013b) can be applied if $(q-\bar{q})(p-\bar{p}) > 0$. It then tells us that for product $k = H, L$, quality is salient if and only if

$$q_k \gtrless \bar{q} \ , \quad p_k \gtrless \bar{p} \quad \text{with} \quad \frac{q_k}{p_k} \gtrless \frac{\bar{q}}{\bar{p}}. \tag{39}$$

For product k, this implies that quality is salient if and only if the decoy is such that

$$p_D \gtrless q_D \frac{p_k}{q_k} + q_{-k}\left(\frac{p_k}{q_k} - \frac{p_{-k}}{q_{-k}}\right) \equiv \bar{p}_k \quad \text{with} \quad q_k \gtrless \bar{q} \quad \text{and} \quad p_k \gtrless \bar{p}. \tag{40}$$

The symmetry of the salience function further allows us to determine the salience of attributes for products with $(q-\bar{q})(p-\bar{p}) < 0$. By definition, quality is salient if and only if

$$\sigma(q,\bar{q}) > \sigma(p,\bar{p}) \underbrace{=}_{symmetry} \sigma(\bar{p},p).$$

Homogeneity of degree 0 of the salience function then gives us a condition for quality salience which is similar to the condition in the previous case:

$$\sigma\left(\frac{q}{\bar{q}},1\right) > \sigma\left(\frac{\bar{p}}{p},1\right) \Leftrightarrow \frac{q}{\bar{q}} \gtrless \frac{\bar{p}}{p} \quad \text{when} \quad q \gtrless \bar{q} \quad \text{and} \quad p \lessgtr \bar{p}. \tag{41}$$

In our case of three products, this implies that quality is salient for product k if the price of the decoy satisfies

$$p_D \lessgtr \frac{9q_k p_k}{q_k + q_{-k} + q_D} - p_k - p_{-k} \equiv \bar{\bar{p}}_k \quad \text{with} \quad q_k \gtrless \bar{q} \quad \text{and} \quad p_k \lessgtr \bar{p}. \tag{42}$$

Conditions (40) and (42) as well as the conditions for $q_k \gtrless \bar{q}$ and $p_k \gtrless \bar{p}$ allow us to partition the quality-price space. In Figure 2.7, I do so for the case in which

$$\frac{q_H}{p_H} < \frac{q_L}{p_L} \quad \text{with} \quad q_H > q_L \quad \text{and} \quad p_H > p_L, \tag{43}$$

since this is always true for the optimal separating products given the same attribute is salient for product L and H. If the decoy (q_D, p_D) lies in the gray area, the high-quality product H's quality is salient. In the dotted area, product L's quality is salient.

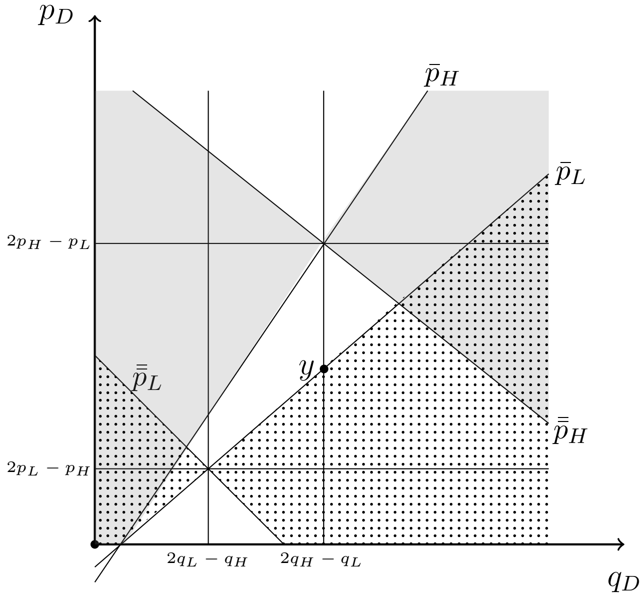

Figure 2.7: **Possible decoys to make both products' quality salient.** Quality is salient for product L if and only if product D lies in the dotted area. Quality is salient for product H if and only if product D lies in the gray area.

In order to make quality salient for both products L and H, we need a decoy where the two areas overlap. Additionally, if it should serve as a decoy, it must not be preferred by neither of the types of consumers. We can derive sufficient conditions under which such a decoy does not exist.

Lemma 2.3. *Given separating products* (q_H, p_H) *and* (q_L, p_L)*, quality is never salient for both products if* $2q_L - q_H < q_D < 2q_H - q_L$.

The proof can be found in the Appendix. Lemma 2.3 implies that a low-quality product can only serve as a decoy if it has quality $q_D \leq 2q_L - q_H$. Given the optimal products for quality salience, this implies that there exists no low-quality decoy with non-negative quality if the share of high types is high:

$$0 > 2q_L^q - q_H^q \Leftrightarrow \alpha > 2\theta - 1 \equiv \bar{\alpha}_1(\theta). \tag{44}$$

This condition is always fulfilled if $\theta < \frac{1}{2}$. Note that $\theta < 1$ implies that there is always a range of α for which separation is possible but no decoy exists: $\alpha \in [2\theta - 1, \theta]$.

The high-quality decoys all have non-negative quality since they must have $q_D > 2q_H - q_L > 0$. However, since we cannot increase the price too much without drawing attention towards the price, consumers might prefer to buy the high-quality decoy. I define product y as the product with quality $q_y = 2q_H^q - q_L^q$ and the price $p_y = \bar{p}_L(q_y)$. Consider situations in which the high type prefers product y to the optimal quality salient product H even if product y was price salient (this implies he would also prefer the decoy if its quality was salient):

$$q_H^q - \delta p_H^q < \delta q_y - p_y. \tag{45}$$

This condition is true if and only if the share of high types is high enough:

$$\alpha > \frac{(1-\theta)\theta\delta + (2\theta - \delta^2)(2-\theta) - 1}{(1-\delta)(\delta+\theta)} \equiv \bar{\alpha}_2(\theta, \delta), \tag{46}$$

and the valuation of the low type is not too high:

$$\theta < \frac{1+\delta+\delta^2}{2+\delta}. \tag{47}$$

From (40), we know that if $q_D > q_y$, a necessary condition for product L to be quality salient is $p_D < \bar{p}_L(q_D)$. Furthermore, given price salience, product y lies on the indifference curve $p_D = \delta q_D - U_y$ with $U_y = \delta q_y - p_y$. If $\theta < \delta^2$, the indifference curve is steeper in q_D than $\bar{p}_L$, so if type H prefers a price salient product y over a quality salient product H, he would also prefer any other high-quality decoy that makes quality salient, even if its price was salient. $\theta < \delta^2$ implies that (47) is satisfied and thus (46) and $\theta < \delta^2$ are sufficient conditions for the non-existence of a high-quality decoy.

The threshold $\bar{\alpha}_1(\theta)$ together with the condition $\theta < \delta^2$ implies that $\bar{\alpha}_1(\theta) > \bar{\alpha}_2(\theta, \delta)$. Hence, we found sufficient conditions and no decoy exists if $\alpha > \bar{\alpha}_1(\theta)$ and $\theta < \delta^2$.

Since exclusion and pooling always allow for quality salience, the trade-off between strategies is the same as in the benchmark case whenever a decoy can be found. However, in situations in which no decoy can be found, the monopolist cannot separate and make quality salient for both optimally separating products. The monopolist has to choose an alternative strategy if he wants to separate, as for example adapt products such that a decoy exists or choosing a decoy that makes type H focus on quality and type L focus on price etc.[6] These strategies give lower profits than separation with optimally separating products given quality salience. Hence, separation is again costly and will possibly not be chosen as often as in the benchmark case even if we abstract from development costs for a third product.

It is always possible for the monopolist to find a decoy which makes the high-quality product quality salient and the low-quality product price salient given the monopolist's optimal products for such salience. Whenever separation with price salience is the optimal strategy given the restriction of two products, the strategy to make product H quality salient is possible and yields higher profits.

Proposition 2.7. *The monopolist always benefits from offering a decoy product.*

The proof is in the Appendix. If the high-quality product becomes quality salient, the monopolist can increase p_H and benefit from the higher willingness to pay of the high type. The monopolist will thus always offer a decoy when separating consumer types. If it is optimal to make product H quality salient and product L price salient, this decoy has an intermediate quality and price but a low quality-price ratio. As shown before, the monopolist also benefits from decoys when he optimally excludes or pools.

2.6.2 Multiple decoys

While the monopolist is not always able to induce quality salience with a single decoy, it might be possible with multiple decoys. It turns out that

[6]The determination of the optimal strategy of the monopolist in this case is left to future work.

the monopolist can always make separating products quality salient if he can offer enough decoys.

Proposition 2.8. *The monopolist can separate while making quality salient for the separating products. In addition to the optimally separating products* (q_H^q, p_H^q) *and* (q_L^q, p_L^q)*, he can offer* $\hat{d}$ *decoys with*

$$q_D = 0 \quad \text{and} \quad p_D = \frac{1}{\hat{d}}\left[\frac{(\hat{d}+2)^2 q_L^q p_L^q}{q_H^q + q_L^q} - p_L^q - p_H^q\right],$$

where $\hat{d}$ *is the smallest integer greater than or equal to*

$$\underline{d} \equiv (q_H^q + q_L^q)\left(\frac{p_H^q}{p_L^q q_H^q q_L^q}\right)^{\frac{1}{2}} - 2.$$

This is a sufficient condition.

To get these insights, I define an M-decoy, which is determined by all decoys offered. The attribute values of the M-decoy are defined as the sum of the attribute values of the single decoys i, $i = 1, ..., d$: $q_M = \sum_{i=1}^{d} q_i$ and $p_M = \sum_{i=1}^{d} p_i$. We can draw the graph with the sum of the decoy-qualities on the horizontal and the sum of the decoy-prices on the vertical. In the same way as for one decoy, we can then determine the areas in which the M-decoy must lie to make quality salient for the products (q_H^q, p_H^q) and (q_L^q, p_L^q). If $(q_k - \bar{q})(p_k - \bar{p}) > 0$, for product $k = H, L$, quality is salient if and only if the M-decoy is such that

$$p_M \gtrless \bar{p}_k(q_M) \text{ with } q_k \gtrless \bar{q} \text{ and } p_k \gtrless \bar{p}. \tag{48}$$

If $(q_k - \bar{q})(p_k - \bar{p}) < 0$, quality is salient for product k if and only if the price of the M-decoy satisfies

$$p_M \lesseqgtr \frac{(d+2)^2 q_k^q p_k^q}{q_{-k}^q + q_k^q + q_M} - p_k^q - p_{-k}^q \equiv \bar{\bar{p}}_k^M(q_M) \text{ with } q_k \gtrless \bar{q} \text{ and } p_k \lesseqgtr \bar{p}. \tag{49}$$

In order to make quality salient for both products H and L, the M-decoy has to lie in the gray and dotted area in Figure 2.8, i.e. either $q_M < (d+1)q_L - q_H$ and $\bar{p}_H(q_M) < p_M < \bar{\bar{p}}_L^M(q_M)$ or $q_M > (d+1)q_H - q_L$ and $\bar{\bar{p}}_H^M(q_M) < p_M < \bar{p}_L(q_M)$.

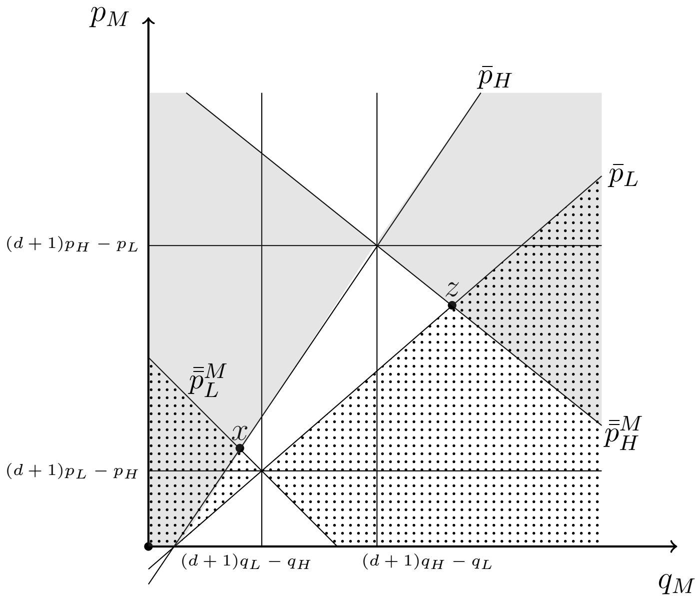

Figure 2.8: **Possible M-decoys that make both products quality salient.** Quality is salient for product L if and only if product M lies in the dotted area. Quality is salient for product H if and only if product M lies in the gray area.

Product x is the low-quality M-decoy with the highest quality:

$$p_x = \arg\max \tilde{q} \quad \text{with} \quad \tilde{q} = \min\left\{\bar{p}_H^{-1}(q), \bar{\bar{p}}_L^{M-1}(q)\right\}. \tag{50}$$

While the inverse of $\bar{p}_H(q)$ is increasing in p_x, the inverse of $\bar{\bar{p}}_L^M(q)$ is decreasing in p_x. Hence, the minimum is maximized if the two arguments are equalized and we get the following expressions for product x:

$$p_x = (d+2)\left(\frac{q_L^q}{q_H^q} p_H^q p_L^q\right)^{\frac{1}{2}} - p_H^q - p_L^q, \tag{51}$$

$$q_x = (d+2)\left(\frac{p_L^q}{p_H^q} q_H^q q_L^q\right)^{\frac{1}{2}} - q_H^q - q_L^q. \tag{52}$$

These values are always such that

$$q_x \leq (d+1)q_L^q - q_H^q \tag{53}$$

and

$$(d+1)p_L^q - p_H^q \leq p_x \leq (d+1)p_H^q - p_L^q \tag{54}$$

and thus, quality is indeed salient for both products.

Adding more decoys increases the quality of product x. Thus, more decoys make it more likely that it has non-negative quality. The number of decoys d must be higher than $\underline{d}$ to guarantee the decoys have non-negative quality:

$$q_x \geq 0 \Leftrightarrow d \geq \underline{d} = (q_H^q + q_L^q) \left(\frac{p_H^q}{p_L^q q_H^q q_L^q} \right)^{\frac{1}{2}} - 2. \tag{55}$$

The lowest integer that is higher than $\underline{d}$ is thus a sufficient number of decoys.

In order to make sure that both types would not prefer the single decoys, we can use zero quality for the M-decoy. Zero quality and a positive price for the M-decoy makes sure that the single decoys would also have zero quality and a positive price, which would give negative utility to consumers.

We know that $(d+1)q_L^q - q_H^q > q_x > 0$ and this implies that $\bar{\bar{p}}_L^M(0) > (d+1)p_L^q - p_H^q$. From conditions (48) and (49), we know that quality is then salient for both products L and H either if $(d+1)p_H^q - p_L^q > \bar{\bar{p}}_L^M(0)$ and $\bar{p}_H(0) < p_M < \bar{\bar{p}}_L^M(0)$ or if $(d+1)p_H^q - p_L^q < \bar{\bar{p}}_L^M(0)$ and $p_M < \min[\bar{\bar{p}}_L^M(0), \bar{\bar{p}}_H^M(0)] = \bar{\bar{p}}_L^M(0)$. Hence, the highest price we can ask for that still makes quality salient for both products given $q_M = 0$ is determined by $\bar{\bar{p}}_L^M(0)$:

$$p_M(q_M = 0) = \frac{(d+2)^2 q_L^q p_L^q}{q_H^q + q_L^q} - p_L^q - p_H^q. \tag{56}$$

This price is increasing in d and thus always positive for $d \geq \underline{d}$ since

$$p_M(q_M = 0)|_{\underline{d}} = (p_H^q \frac{q_L^q}{q_H^q} - p_L^q) = \frac{q_L^q (q_H^q - q_L^q)(1-\theta)}{q_H^q} > 0. \tag{57}$$

Condition (55) is sufficient but might not be necessary, since there could be a high-quality M-decoy. If we assume there is an upper bound on quality $\hat{q}$, the assumption implies that the single decoys cannot have quality higher than $\hat{q}$, i.e. $q_M \leq d \cdot \hat{q}$. From the high-quality M-decoys which make quality salient for H and L, product z is most likely to satisfy this condition:

$$p_z = \arg\min \tilde{q}' \quad \text{with} \quad \tilde{q}' = \max \left\{ \bar{p}_L^{-1}(q), \bar{\bar{p}}_H^{M-1}(q) \right\}. \tag{58}$$

Since the two inverse functions move in opposite directions when changing p, the maximum in minimized if they are just equal. Given the optimal products, the lowest high-quality decoy has quality

$$q_z = (d+2)\left(\frac{p_H^q}{p_L^q} q_H^q q_L^q\right)^{\frac{1}{2}} - q_H^q - q_L^q. \tag{59}$$

These values are always such that

$$q_z \geq (d+1)q_H^q - q_L^q \tag{60}$$

and

$$(d+1)p_L^q - p_H^q \leq p_z \leq (d+1)p_H^q - p_L^q \tag{61}$$

and thus, quality is indeed salient for both products.

If we use it as M-decoy, the quality of each decoy q_D must be feasible to produce:

$$\begin{aligned} q_D = \frac{q_z}{d} &\leq \hat{q} \\ \Leftrightarrow \hat{q} &\geq \frac{d+2}{d}\left(\frac{p_H^q}{p_L^q} q_H^q q_L^q\right)^{\frac{1}{2}} - \frac{1}{d}(q_H^q + q_L^q). \end{aligned} \tag{62}$$

The RHS is increasing in d:

$$\frac{\partial \frac{q_z}{d}}{\partial d} = -\frac{1}{d^2}\left[2\sqrt{\frac{q_H}{\theta}(q_H - (1-\delta)q_L)} - q_H - q_L\right] < -\frac{1}{d^2}(q_H - q_L) < 0. \tag{63}$$

Hence, $d > 1$ will not fulfill the restriction whenever $d = 1$ does not, i.e. whenever the upper bound on quality is low:

$$\hat{q} < 3\left(\frac{p_H^q}{p_L^q} q_H^q q_L^q\right)^{\frac{1}{2}} - q_H^q - q_L^q. \tag{64}$$

Therefore, condition (55) is necessary and sufficient to make quality salient if the monopolist wants to separate with the optimal products L and H and there is an upper bound on quality $\hat{q} < q_z(d=1)$. Without the upper bound on quality, (55) is sufficient but might not be necessary.

2.6.3 General utility function

Given the salience of an attribute is determined by the subjective utility from quality rather than the objective quality, the result that a monopolist is less prone to separate if he faces consumers with salience-driven preferences does not depend on the linearity of preferences. Consider consumers with experience utility that is nonlinear in the taste parameter θ_i, i.e. $u(q, \theta_i) - p$, with $u(q, \theta_i)$ increasing and concave in q and satisfying the single crossing property, i.e. the marginal utility of quality increases in θ_i. With such experience utility, different types might focus on different attributes. Given two products (q_L, p_L) and (q_H, p_H), with $q_H > q_L$ and $p_H > p_L$, a consumer i focuses on quality if and only if

$$\frac{u(q_H, \theta_i)}{p_H} > \frac{u(q_L, \theta_i)}{p_L}. \tag{65}$$

I show in the following that the monopolist again always separates with products that make both consumer types focus on price, while he excludes and pools with a decoy that implies quality salience.

Similar to Lemma 2.1, the monopolist cannot separate the types without making the low type focus on price. Consider a consumer with utility function $\gamma u(q, \theta_i) - \omega p$, with $\gamma \in (0, 1]$ and $\omega \in (0, 1]$,[7] and two products L and H with $q_H \geq q_L$ and $p_H \geq p_L$. It is impossible to make type L focus on quality while satisfying his participation and his incentive compatibility constraint. Assume (q_L, p_L) satisfies the participation constraint of type L, i.e. $\gamma u(q_L, \theta_L) - \omega p_L \geq 0$. If the monopolist wants to separate, the high-quality product has to satisfy

$$p_H \geq \frac{\gamma}{\omega}[u(q_H, \theta_L) - u(q_L, \theta_L)] + p_L. \tag{66}$$

In order to make quality salient, the high-quality product has to satisfy

$$p_H < \frac{u(q_H, \theta_L)}{u(q_L, \theta_L)} p_L. \tag{67}$$

[7]Note that $\gamma = 1$ and $\omega = \delta$ captures quality salience while $\gamma = \delta$ and $\omega = 1$ captures price salience and $\gamma = 1$ and $\omega = 1$ is equivalent to neutral salience. Hence, the following analysis shows that separation results in type L focusing on price in all three cases.

To find such a product is possible if and only if

$$\frac{u(q_H,\theta_L)}{u(q_L,\theta_L)}p_L > \frac{\gamma}{\omega}[u(q_H,\theta_L) - u(q_L,\theta_L)] + p_L \Leftrightarrow \frac{p_L}{u(q_L,\theta_L)} > \frac{\gamma}{\omega}, \tag{68}$$

which violates the participation constraint PC_L. Hence, it is impossible to separate consumers and induce type L to focus on quality. Separating with no attribute being salient for the low type is possible but would imply that the monopolist optimally offers the same product to both consumers. The neutral salience condition $p_H = p_L \frac{u(q_H,\theta_L)}{u(q_L,\theta_L)}$ and the IC_L given neutral salience together imply that $p_L \geq u(q_L,\theta_L)$. Considering the PC_L given neutral salience, it follows that $p_L = u(q_L,\theta_L)$ and thus $p_H = u(q_H,\theta_L)$. It is then profit-maximizing for the monopolist to offer the same product to both types. However, this strategy is always dominated by pooling with a decoy that makes quality salient (we see later in this section that pooling with quality salience is always possible).

While type L thus necessarily focuses on price whenever separation is optimal, the monopolist could design the products such that quality is salient for type H. However, quality salience requires the price of the high-quality product to be rather low. It turns out that this restriction on the price p_H is so strong, that the monopolist prefers to increase the price and let type H focus on price too. To see this, note that type H focuses on quality if and only if the price p_H is not too high:

$$p_H < \frac{u(q_H,\theta_H)}{u(q_L,\theta_H)}p_L. \tag{69}$$

Inducing quality salience for the high type is beneficial if and only if the quality salience condition (69) is less restrictive than the IC_H given price salience, i.e. if and only if

$$\delta[u(q_H,\theta_H) - u(q_L,\theta_H)] + p_L < \frac{u(q_H,\theta_H)}{u(q_L,\theta_H)}p_L \Leftrightarrow \delta < \frac{p_L}{u(q_L,\theta_H)}. \tag{70}$$

This is never true since condition (70) violates the participation constraint of type L. Similarly, inducing neutral salience for type H is not optimal, since it requires

$$p_H = \frac{u(q_H,\theta_H)}{u(q_L,\theta_H)}p_L. \tag{71}$$

Replacing the strict inequalities in (70) with weak inequalities shows that this condition is again more restrictive than the IC_H given price salience. Hence, the result that the monopolist separates with price salient products and thus separation is less beneficial than in the benchmark case holds for more general utility functions.

When the monopolist wants to exclude low types or pools, it is again possible to offer a decoy that makes quality salient for both types. I prove the existence of such decoys in the Appendix. Since separation comes at a cost while pooling and exclusion benefit from quality salience, it follows that the monopolist is less likely to separate consumers with salience-driven preferences.

Considering the trade-off between pooling and exclusion, nothing changes when consumers have salience-driven preferences. When the monopolist pools, he chooses the quality in order to maximize $u(q_P, \theta_L) - \frac{1}{2}q_P^2$. When he wants to exclude the low types, he offers the quality that maximizes $\alpha[u(q_E, \theta_H) - \frac{1}{2}q_E^2]$. Since $\theta_L \to \theta_H$ implies that $q_P \to q_E$, pooling is preferred to exclusion if the valuations do not differ too much and the share of high types α is low.

If the salience of quality is determined by the objective quality, the results from Section 2.5 rely on the linearity of the indifference curves in quality. Each indifference curve then only cuts the constant ratio line once, which is important for Lemma 2.1. With decreasing marginal utility of quality, a higher quality product with higher quality-price ratio would not necessarily be preferred by the consumers.

2.6.4 General cost function

It is possible to show that the results from Section 2.5 hold for all cost functions with $c'(q) > 0$ and $c''(q) > 0$. The proofs of the Lemmas are independent of the monopolist's cost. The monopolist's possible strategies are thus still to separate with price salience, exclude or pool with quality salient products. Price salience decreases the willingness to pay of a consumer compared to the benchmark case. Therefore, separation will be less profitable in case of salience-driven consumer preferences. To show this, consider the profit of separation with price salience, where q_H^* and q_L^* are the profit-maximizing qualities given δ:

$$\pi_S(\delta) = \alpha[\delta(q_H^* - q_L^*) + \delta\theta q_L^* - c(q_H^*)] + (1-\alpha)[\delta\theta q_L^* - c(q_L^*)]. \tag{72}$$

If salience becomes weaker, i.e. δ increases by $\Delta\delta$, the monopolist can increase the price p_H by $\Delta\delta[(q_H^* - q_L^*) + \theta q_L^*]$ and price p_L by $\Delta\delta\theta q_L^*$, which strictly increases his profits and leaves the salience of attributes unchanged. Additionally, the monopolist could adapt the qualities of the products he offers, but he would do so only if it was profitable. The profit of separation thus strictly increases if salience becomes weaker.

In contrast, quality salience increases the willingness to pay and exclusion and pooling become more profitable. The maximal profit of exclusion given salience parameter δ amounts to

$$\pi_E(\delta) = \alpha[\frac{1}{\delta}q_E^* - c(q_E^*)]. \tag{73}$$

If salience becomes stronger, i.e. δ decreases by $\Delta\delta$, the monopolist can increase price p_E by $\left[\frac{1}{\delta-\Delta\delta} - \frac{1}{\delta}\right] q_E^*$ and the high type would still be willing to buy it given its quality is still salient. In Section 2.5.3, we showed that the monopolist can indeed always find a decoy that makes product E quality salient whenever product E satisfies the participation constraint. Therefore, stronger salience strictly increases the monopolist's profit. Adapting q_E could additionally increase the profit.

The maximal profit of pooling given salience parameter δ amounts to

$$\pi_P(\delta) = \frac{1}{\delta}\theta q_P^* - c(q_P^*). \tag{74}$$

If salience becomes stronger, i.e. δ decreases by $\Delta\delta$, the monopolist can increase price p_P by $\left[\frac{1}{\delta-\Delta\delta} - \frac{1}{\delta}\right] \theta q_P^*$ and both types still buy product P given quality is still salient. From Section 2.5.4, we know there is a decoy that makes quality salient given a pooling product that satisfies the participation constraints. Hence, stronger salience strictly increases profits and adapting q_P could even increase these gains.

Profits from exclusion and pooling thus strictly increase in the strength of salience, while the profit from separation decreases. There is again a cost of separation and a benefit to exclusion and to pooling. In case of salience-driven preferences and two products on offer, the parameter range for which the monopolist chooses to separate the consumer types is smaller.

2.7 Conclusion

In this paper, I investigate the effect of salient thinking of consumers on the prevalence of (monopolistic) price discrimination. In my model, a monopolist faces consumers with salience-driven preferences who are heterogeneous in their valuation of quality. When designing his products, the monopolist has to take into account the products' influence on the salience of their attributes. Consumers give a higher weight to the attribute which varies more within the choice set. In the case of two types of consumers, it turns out that a monopolist is less likely to price discriminate when consumers have salience-driven preferences.

The optimally separating products always induce price salience, which reduces the willingness to pay of the consumers. If the monopolist is restricted to offer two products, he can thus not avoid price salience when separating. When excluding low types or pooling, the monopolist can offer a decoy that lets consumers focus on quality.

Allowing the monopolist to offer more products, he might be able to induce quality salience also when separating by additionally offering decoy products. It turns out that this is always possible if the monopolist can offer sufficiently many decoys. Whenever it is costly to develop such decoys, the monopolist is less likely to separate than in the case of consumers with standard preferences.

Future research should concentrate on characterizing the complete optimal strategy of the monopolist given more than two versions of a product are possible. Furthermore, one could introduce an exogenous offer by another firm. If this offer yields negative utility to the consumers, the monopolist can increase his prices. At a higher level of prices, it is less likely that the same price difference induces price salience and the monopolist might be able to separate with products that induce quality salience.

It would also be interesting to test empirically whether indeed consumers focus on price if the monopolist separates. Furthermore, one could test whether a monopolist always offers products with the intention to influence attention. This should be more likely to be observed if development costs of decoys are low.

2.8 Appendix

2.8.1 Proof of Lemma 2.1

Consider two products L and H with $q_H \geq q_L$ and $p_H \geq p_L$. Assume (q_L, p_L) satisfies the participation constraint $\gamma q_L - \omega p_L \geq 0$, with $\gamma \in (0,1]$ and $\omega \in (0,1]$:

$$\gamma q_L - \omega p_L \geq 0 \tag{75}$$
$$\Rightarrow \frac{p_L}{q_L} \leq \frac{\gamma}{\omega} \tag{76}$$
$$\Rightarrow \frac{p_L}{q_L}(q_H - q_L) \leq \frac{\gamma}{\omega}(q_H - q_L) \tag{77}$$
$$\Leftrightarrow \frac{\gamma}{\omega} q_L - p_L \leq \frac{\gamma}{\omega} q_H - q_H \frac{p_L}{q_L}. \tag{78}$$

Quality salience ($p_H < q_H \frac{p_L}{q_L}$) implies:

$$\Rightarrow \frac{\gamma}{\omega} q_L - p_L < \frac{\gamma}{\omega} q_H - p_H \tag{79}$$
$$\Leftrightarrow \gamma q_L - \omega p_L < \gamma q_H - \omega p_H. \tag{80}$$

The product (q_H, p_H) is strictly preferred by the consumer.

This lemma shows that both types would prefer product H, independent of which attribute is salient. Considering the low type, $\gamma = \theta$ and $\omega = \delta$ captures the case of quality salience, $\gamma = \theta$ and $\omega = 1$ captures the case of neutral salience and $\gamma = \delta\theta$ and $\omega = 1$ captures the case of price salience. Considering the high type, $\gamma = 1$ and $\omega = \delta$ captures the case of quality salience, $\gamma = 1$ and $\omega = 1$ captures the case of neutral salience and $\gamma = \delta$ and $\omega = 1$ captures the case of price salience.

2.8.2 Separation with neutral salience

If quality salience and separation is not possible, the monopolist can try to separate while keeping salience neutral. Salience is neutral, i.e. consumers give equal weights to quality and price, if the two quality-price ratios are equal. The monopolist then takes into account the participation constraints and the incentive compatibility constraints of the benchmark case.

The IC_L and the neutral salience condition $p_H = \frac{q_H}{q_L} p_L$ imply that $p_L \geq \theta q_L$. Together with the participation constraint of the low type, this means that $p_L = \theta q_L$ and hence $p_H = \theta q_H$.

The monopolist therefore maximizes profits:

$$\max_{q_H, q_L} \; \alpha(\theta q_H - \frac{1}{2} q_H^2) + (1-\alpha)(\theta q_L - \frac{1}{2} q_L^2). \tag{81}$$

It follows that the optimal product is the same for both types, i.e. the monopolist would pool the types. Even though there exist two products with which the monopolist can separate the types and make no attribute salient, such separation is dominated by pooling with neutral consumers. I show in Subsection 2.5.4 that the monopolist can always pool with quality salience. Pooling with neutral consumers is thus always dominated.

2.8.3 Proof of Lemma 2.2

Consider two products E and D with $q_E \geq q_D$ and $p_E \geq p_D$. Assume (q_E, p_E) satisfies the participation constraint $\gamma q_E - \omega p_E \geq 0$:

$$\Rightarrow \frac{p_E}{q_E} \leq \frac{\gamma}{\omega} \tag{82}$$

$$\Rightarrow \frac{p_E}{q_E}(q_E - q_D) \leq \frac{\gamma}{\omega}(q_E - q_D) \tag{83}$$

$$\Leftrightarrow \frac{\gamma}{\omega} q_D - q_D \frac{p_E}{q_E} \leq \frac{\gamma}{\omega} q_E - p_E. \tag{84}$$

Quality salience ($p_D > q_D \frac{p_E}{q_E}$) implies:

$$\Rightarrow \frac{\gamma}{\omega} q_D - p_D < \frac{\gamma}{\omega} q_E - p_E \tag{85}$$

$$\Leftrightarrow \gamma q_D - \omega p_D < \gamma q_E - \omega p_E. \tag{86}$$

This lemma shows that both types would strictly prefer product E, independent of which attribute is salient. Considering the low type, $\gamma = \theta$ and $\omega = \delta$ captures the case of quality salience, $\gamma = \theta$ and $\omega = 1$ captures the case of neutral salience and $\gamma = \delta\theta$ and $\omega = 1$ captures the case of price salience. Considering the high type, $\gamma = 1$ and $\omega = \delta$ captures the case of quality salience, $\gamma = 1$ and $\omega = 1$ captures the case of neutral salience and $\gamma = \delta$ and $\omega = 1$ captures the case of price salience.

2.8.4 Proof of Lemma 2.3

Given separating products (q_H, p_H) and (q_L, p_L), quality is never salient for both products if $2q_L - q_H < q_D < 2q_H - q_L$.

Consider $q_D \in [2q_L - q_H, 2q_H - q_L]$.

- *Case 1*: $p_D < 2p_L - p_H$

  Product H cannot be quality salient since quality salience would require $p_D > \bar{p}_H$. This is impossible with $p_D < 2p_L - p_H$ because then $\bar{p}_H > 2p_L - p_H$ whenever $q_D > 3\frac{q_H}{p_H}p_L - q_H - q_L$ which is true for our range of q_D and any separating products, i.e. if $\frac{q_H}{p_H} < \frac{q_L}{p_L}$.

- *Case 2*: $2p_L - p_H < p_D < 2p_H - p_L$

  Product H's quality is salient if $p_D > \bar{p}_H$ and product L's quality is salient if $p_D < \bar{p}_L$. It is impossible to satisfy both conditions since $\bar{p}_H > \bar{p}_L$ whenever $\frac{q_H}{p_H} < \frac{q_L}{p_L}$, which is true for any separating products.

- *Case 3*: $p_D > 2p_H - p_L$

  Product L cannot be quality salient since quality salience would require $p_D < \bar{p}_L$. This is impossible with $p_D > 2p_H - p_L$ since $\bar{p}_L < 2p_H - p_L$ whenever $q_D < 3\frac{q_L}{p_L}p_H - q_H - q_L$ which is true for our range of q_D and any separating products, i.e. if $\frac{q_H}{p_H} < \frac{q_L}{p_L}$.

2.8.5 Proof of Proposition 7

Optimal separating products if quality is salient for product H and price is salient for product L

Maximization problem of the monopolist:

$$\begin{aligned} \max_{p_H, p_L} \quad & \alpha(p_H - \frac{1}{2}q_H^2) + (1-\alpha)(p_L - \frac{1}{2}q_L^2) & \\ \text{s.t.} \quad & \delta\theta q_L - p_L \geq 0 & PC_L \\ & q_H - \delta p_H \geq 0 & PC_H \\ & \delta\theta q_L - p_L \geq \theta q_H - \delta p_H & IC_L \\ & q_H - \delta p_H \geq \delta q_L - p_L & IC_H \end{aligned}$$

The PC_L and the IC_H imply that the PC_H is redundant. The incentive compatibility constraints imply that $q_H \geq \delta q_L$. Increasing p_H increases profits, so the IC_H will be binding. The IC_L then becomes redundant. Increasing p_L increases profits until the PC_L is binding.

$$\max_{q_H, q_L} \quad \alpha[\frac{1}{\delta}q_H - q_L(1-\theta) - \frac{1}{2}q_H^2] + (1-\alpha)[\delta\theta q_L - \frac{1}{2}q_L^2] \tag{87}$$

$$\text{s.t.} \quad q_H \geq \delta q_L \tag{88}$$

The monopolist can choose q_L and q_H optimally:

$$q_L^{qp} = \delta\theta - \frac{\alpha}{1-\alpha}(1-\theta) \qquad \text{and} \qquad q_H^{qp} = \frac{1}{\delta}. \tag{89}$$

These optimal qualities always satisfy the condition $q_H \geq \delta q_L$, since we always have $q_H \geq 1$ and $q_L \leq 1$.

Since I assume that qualities are non-negative, the maximization problem has a corner solution, $q_L^{qp} = 0$, if the valuation of the low type is too low:

$$\theta \leq \frac{\alpha}{\delta(1-\alpha)+\alpha} \equiv \hat{\theta}_4(\alpha). \tag{90}$$

However, the monopolist is then better off by excluding the low type.

Existence of decoy that makes quality salient for product H and price salient for product L

First note that given such salience, the IC_L implies that $p_H \geq \theta(\frac{1}{\delta}q_H - q_L) + \frac{1}{\delta}p_L$. Together with the PC_L it thus follows that $\frac{p_H}{q_H} > \frac{1}{\delta}\theta$. Furthermore, we know from PC_L that $\frac{p_L}{q_L} \leq \delta\theta$. Thus, it must be that any separating products given such salience are such that

$$\frac{q_H}{p_H} < \frac{q_L}{p_L}. \tag{91}$$

Further, we found that the optimal products derived above are always such that $q_H \geq q_L$ and $p_H \geq p_L$ since $p_H = \frac{1}{\delta}q_H - q_L + \frac{1}{\delta}p_L \geq p_L$. Given the optimal products, we want to find a decoy which makes quality salient for product H and price salient for product L. We thus need a decoy such that the following holds:

$$\frac{\bar{q}}{\bar{p}} < \frac{q_H}{p_H} < \frac{q_L}{p_L}, \tag{92}$$

$$q_L < \bar{q} < q_H, \tag{93}$$

$$p_L < \bar{p} < p_H. \tag{94}$$

For the decoy, this implies it has to lie in the hatched area in Figure 2.9, where

$$p_D > q_D\frac{p_H}{q_H} + q_L\left(\frac{p_H}{q_H} - \frac{p_L}{q_L}\right), \tag{95}$$

$$2q_H - q_L > q_D > 2q_L - q_H, \tag{96}$$

$$2p_H - p_L > p_D > 2p_L - p_H. \tag{97}$$

Consider for example the product $q_D = q_L$ and $p_D = 2p_H - p_L - e$. It easily satisfies conditions (96) and (97) when $e \to 0$. Furthermore, it satisfies (95) for $e \to 0$:

$$2p_H - p_L - e > q_L\frac{p_H}{q_H} + q_L\left(\frac{p_H}{q_H} - \frac{p_L}{q_L}\right) \Leftrightarrow e < 2p_H\left(1 - \frac{q_L}{q_H}\right). \tag{98}$$

Without determining which attribute is salient for the decoy, it is enough to show that both types would not buy it even if it was quality is salient.

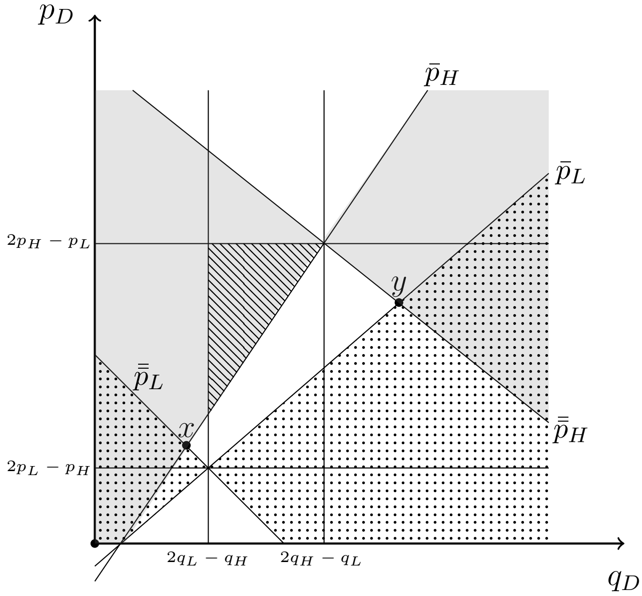

Figure 2.9: **Possible decoys to make consumers focus on the quality of product H and on the price of product L.** Quality is salient for product L if and only if product D lies in the dotted area. Quality is salient for product H if and only if product D lies in the gray area. In the hatched area, quality is salient for product H and price is salient for product L.

The high type does not prefer the decoy if and only if

$$q_D - \delta p_D < q_H - \delta p_H \tag{99}$$

$$\Leftrightarrow e < p_H - p_L + \frac{1}{\delta}(q_H - q_L). \tag{100}$$

The low type does not prefer the decoy if

$$\theta q_D - \delta p_D < \delta\theta q_L - p_L \tag{101}$$

$$\Leftrightarrow e < 2p_H - p_L\left(\frac{1}{\delta} + 1\right) - \theta q_L\left(\frac{1}{\delta} - 1\right). \tag{102}$$

Plugging in the optimal products, the RHSs of (100) and (102) are strictly positive and thus there exists an $e \to 0$ for which neither of the types prefers the decoy. To see this for the RHS of (102), note that it is strictly increasing in α:

$$\frac{\partial RHS}{\partial \alpha} = \frac{(1-\theta)(\delta^2\theta + (2-2\theta)\delta + \theta)}{\delta(1-\alpha)^2} > 0, \tag{103}$$

and already positive at $\alpha = 0$:

$$RHS|_{\alpha=0} = \frac{2}{\delta^2} - \theta^2\delta^2 + (2\theta^2 - 2\theta)\delta - \theta^2 > 0, \tag{104}$$

since $RHS|_{\alpha=0}$ is strictly decreasing in θ:

$$\frac{\partial\, RHS|_{\alpha=0}}{\partial\theta} = -2\delta^2\theta - 2\delta(1-\theta) - 2\theta(1-\delta) < 0, \tag{105}$$

and still positive at $\theta = 1$:

$$RHS|_{\alpha=0,\theta=1} = \frac{2}{\delta^2} - \delta^2 - 1 > 0. \tag{106}$$

Hence, there always exists a decoy that makes quality salient for product H and price salient for product L.

Comparison with profit from separation with price salient products

The monopolist prefers to separate with a decoy if

$$\pi_S^{qp} - \pi_S \geq 0. \tag{107}$$

This difference is decreasing in δ and equal to zero at $\delta = 1$:

$$\frac{\partial[\pi_S^{qp} - \pi_S]}{\partial\delta} = -\frac{\alpha[(1-2\theta+(2-\alpha)\theta^2)\delta^4 + \theta(1-\theta)(1-\alpha)\delta^3 + (1-\alpha)]}{(1-\alpha)\delta^3}. \tag{108}$$

(Note that the expression in the square brackets is decreasing in α and positive at $\alpha = 1$). Hence, whenever both forms of separation exist, the monopolist prefers to induce the high-quality product to be quality salient.

Existence of separation

We can show that whenever separation with price salience would be preferred to exclusion or pooling with a decoy, separation with quality-price salience would also be possible since: $\hat{\theta}_2(\alpha) \geq \hat{\theta}_4(\alpha)$, for all $\alpha \in [0,1]$ and all $\delta \in (0,1]$.

To see this, note that the difference $\hat{\theta}_2(\alpha) - \hat{\theta}_4(\alpha)$ strictly decreases in δ and is equal to zero at $\delta = 1$:

$$\frac{\partial[\hat{\theta}_2(\alpha) - \hat{\theta}_4(\alpha)]}{\partial\delta} = -\frac{2\alpha^{1/2}(1-\alpha)^{1/2}}{(\frac{1}{\delta^4}-1)^{1/2}\delta^5} + \frac{\alpha(1-\alpha)}{[\delta(1-\alpha)+\alpha]^2} < 0 \tag{109}$$

$$\Leftrightarrow T \equiv 4[\delta + (1-\delta)\alpha]^4 - \alpha(1-\alpha)\delta^6(1-\delta^4) > 0. \tag{110}$$

T is positive since it is positive at $\delta = 0$ $[T(\delta = 0) = 4\alpha^4]$ and strictly increasing in δ:

$$\begin{aligned}\frac{\partial T}{\partial\delta} =& 16[\delta^3(1-\alpha)^3 + 2\alpha^2\delta(1-\alpha)(1-\delta) + \alpha^2\delta(1-\alpha) \\ &+ \alpha^3(1-\delta^2) + 2\alpha\delta^2(1-\alpha)^2] + 10\alpha\delta^9 + \alpha\delta^2(16-6\delta^3) > 0.\end{aligned} \tag{111}$$

2.8.6 Proofs with a general utility function

The proof that price is salient for both types whenever the monopolist optimally separates is presented in the main text. I show here that there always exists a decoy that makes quality salient when the monopolist pools or excludes low types.

Exclusion. The optimal excluding product given quality salience (q_E, p_E) satisfies the participation constraint of type H given quality is salient, i.e. $u(q_E, \theta_H) - \delta p_E \geq 0$. Consider a product (q_D, p_D) with $p_D = p_E - \epsilon$ and $q_D \in (0, q_E)$ that satisfies the following conditions:

- It is strictly dominated for type L given quality salience:

$$\epsilon < \frac{1}{\delta}u(q_E, \theta_L) - \frac{1}{\delta}u(q_D, \theta_L). \tag{112}$$

- It is strictly dominated for type H given quality salience:

$$\epsilon < \frac{1}{\delta}u(q_E, \theta_H) - \frac{1}{\delta}u(q_D, \theta_H). \tag{113}$$

- It induces quality salience for type L:

$$\epsilon < p_E\left[1 - \frac{u(q_D, \theta_L)}{u(q_E, \theta_L)}\right]. \tag{114}$$

- It induces quality salience for type H:

$$\epsilon < p_E \left[1 - \frac{u(q_D, \theta_H)}{u(q_E, \theta_H)}\right]. \tag{115}$$

Since the RHSs for all four conditions are strictly positive, there always exists an $\epsilon \to 0$ such that they are all satisfied.

Pooling. The optimal pooling product given quality salience (q_P, p_P) satisfies the participation constraint of type L given quality is salient, i.e. $u(q_P, \theta_L) - \delta p_P \geq 0$. Consider a product (q_D, p_D) with $p_D = p_P - \epsilon$ and $q_D \in (0, q_P)$ that satisfies the following conditions:

- It is strictly dominated for type L given quality salience:

$$\epsilon < \frac{1}{\delta} u(q_P, \theta_L) - \frac{1}{\delta} u(q_D, \theta_L). \tag{116}$$

- It is strictly dominated for type H given quality salience:

$$\epsilon < \frac{1}{\delta} u(q_P, \theta_H) - \frac{1}{\delta} u(q_D, \theta_H). \tag{117}$$

- It induces quality salience for type L:

$$\epsilon < p_E \left[1 - \frac{u(q_D, \theta_L)}{u(q_P, \theta_L)}\right]. \tag{118}$$

- It induces quality salience for type H:

$$\epsilon < p_E \left[1 - \frac{u(q_D, \theta_H)}{u(q_P, \theta_H)}\right]. \tag{119}$$

Since the RHSs for all four conditions are strictly positive, there always exists an $\epsilon \to 0$ such that they are all satisfied.

Chapter 3

Market Interaction and the Focus on Consequences in Moral Decision Making

joint with Ann-Kathrin Crede and Jonas Gehrlein

3.1 Introduction

The discussion about the effects of market interaction on moral behavior can be traced back to Hume and Smith[1]. For some time, the dominant opinion was that markets improve mutual understanding and cooperation (e.g. Montesquieu, 1749; Smith, 1761, 1776). However, other researchers started to promote the thesis that markets erode moral behavior (e.g. Veblen, 1899; Schumpeter, 1942; Hayek, 1948). They claim that market competition promotes the "winner-take-all" mentality, decreases concerns for others and lets people treat moral issues in terms of cost and benefits (Chen, 2011). In recent years, this debate resurfaced and economists contributed with numerous theoretical (e.g. Bowles, 1998; Shleifer, 2004) and experimental studies. Some of these experimental studies find that market interaction indeed decreases the concern for others (e.g. Falk and Szech, 2013; Bartling et al., 2014) while others find a moral enhancing effect of markets (e.g. Henrich et al., 2001; Francois et al., 2009).

Most of this work in economics does not distinguish between preferences over the consequences of an action and the moral costs of taking the action. However, some economists (e.g. Alger and Weibull, 2013; Falk and Tirole, 2016; Casal et al., 2016; Bartling and Özdemir, 2017; Chen and Schonger, 2017) started to consider concepts of morality which originate from philosophy and explicitly distinguish between these two aspects of an action.

There are two fundamentally different concepts in philosophy on how to evaluate the morality of an action: consequentialism and deontology. These concepts can take opposing views on whether an action is morally right or wrong. Immanuel Kant importantly shaped the theory of *deontology*, which suggests that the morality of an action must be evaluated by the action itself (Kant, 1870/1785, 1872/1788). That means, for example, one should kill under no circumstances since killing is not conform with moral norms. In contrast, according to *consequentialism* (to which utilitarianism belongs), the morality of an action is evaluated by its consequences. That is, killing is

[1]For a collection of early statements on the effects of markets on culture see Hirschman (1977) and Hirschman (1982).

bad, but if by killing one person, the death of several other persons can be prevented, killing is considered to be morally right. Evidence shows that many people consider both in their decisions, the consequences and the moral costs of an action (e.g. Ritov and Baron, 1999; Bartels, 2008; Chen and Schonger, 2017). Those individuals choose an action which contradicts moral norms if the effect on consequences is sufficiently beneficial. Such a consequentialist-deontological type might for example not kill one person in order to save two persons but is willing to kill one person to save three. In one situation he behaves according to deontological principles whereas in another he makes decisions according to consequentialism.

We do not intend to take a stance for either moral concept. However, it is important to distinguish between the different concepts, since pure consequentialist logic - which predominated the economic literature for a long time - sometimes fails to explain observed behavior. Furthermore, "theorists argue over deontological and consequentialist theories for criminal policy, contract law, property rights, procedural justice, constitutional interpretation and international law." (Chen 2011, p.4).

Whether decision makers apply either deontological or consequentialist principles is influenced by the context. Paxton et al. (2012) find that completing a Cognitive Reflection Test (CRT) prior to responding to moral dilemmas increases consequentialist responding, i.e. individuals who reflected more on the CRT made more consequentialist judgments. Also emotions can influence which of the two concepts is used in moral decision making. Negative emotions lead to more deontological decisions (Wheatley and Haidt, 2005), the unavailability of emotions comes along with more consequentialist moral judgments (Koenigs et al., 2007). Greene et al. (2001) show how a higher emotional involvement changes decision making. Capraro and Sippel (2017) find that women are more likely than men to apply the deontological concept when emotions are salient in the moral dilemma. The effect of cultural differences is reported by Gold et al. (2014) and Hauser et al. (2007). Such context dependence shows that studying the determinants of moral judgment is of high relevance.

While other studies concentrate on the question whether moral behavior can persist *in* markets, we investigate whether and how the experience of interacting in a market influences moral decision making *outside* the market, i.e. in subsequent decisions.

We design an online experiment in which we let participants play either a market or a non-market game and subsequently confront them with a hypothetical moral dilemma in order to elicit their moral preferences. By letting participants play a market game, more specifically a double auction, we intend to shift the participants' mindset towards cost-benefit considerations. This is related to the method of priming from social psychology which argues that the use of a concept in one task increases the probability of using the same concept in a subsequent, unrelated task (Bargh and Chartrand, 2000). Economists have started to adapt this method to experimental economics (e.g. Benjamin et al., 2010; Chen, 2011; Cohn and Maréchal, 2016). Benjamin et al. (2010) show that priming can influence the salience of attributes, which in turn influences the primed individual's preferences. Their results are in line with the hypothesis that the salience of an attribute increases the weight that is given to this attribute. Instead of the traditional way of priming, which induces a mindset for example by letting participants think or read about a market, we let them have the experience of market interaction directly. In a market, individuals are confronted with cost-benefit considerations. We conjecture that such an experience makes consequences salient. We consider salience together with the moral preferences from Chen and Schonger (2017) to derive our hypothesis. Individuals who *only* care for the consequences or *only* care for the action itself should not be influenced by salience and therefore do not react to a change in the mindset. However, individuals with preferences for both attributes are influenced. Market priming, and thus salient consequences, shifts their moral decisions towards consequentialism.

Giving a higher weight to consequences would imply that certain values or norms (such as you should not lie or steal), that can only become manifest in an action but do not translate into consequences, would lose importance and vanish in decision-making processes. Focusing on consequences could therefore make decisions generally more efficient but less moral from a deontological perspective.

In a related study, Chen (2011) investigates the effect of labor competition on moral decision making. He finds that the effect of competition on moral decisions is affected by how participants relate to markets. In order to account for such a moderator effect of different attitudes towards markets, we use the Fair Market Ideology (FMI) scale of Jost et al. (2003).

The results of the experiment will significantly depend on whether we succeed in changing the mindset of individuals by the use of traditional behavioral games. In order to verify a shift towards a market mindset, we will apply a manipulation check to a sub-sample of our study participants. The manipulation check consists of a word completion task and is designed such that it should detect changes in mindsets regarding markets.

The remainder of the paper is structured as follows. In the next section, we give an overview over the recent literature about the effect of markets on morality and other determinants of moral judgment. In Section 3.3, we describe the design of the experiment. Section 3.4 introduces the preferences from Chen and Schonger (2017) and shows how salience affects them. In Section 3.5, we derive our hypotheses and Section 3.6 presents the pre-analysis plan. Section 3.7 discusses limitations and Section 3.8 concludes.

3.2 Literature

As mentioned in the Introduction, some experiments find that markets have a detrimental effect on moral behavior. Several of these experimental studies consider moral behavior defined as concerns for negative externalities of trade. Those studies analyze the prevalence of moral behavior when varying different influential aspects of a market: competition, diffusion of responsibility, social information and market framing. Plott (1983) find that experimental markets converge to the competitive equilibrium even if trade induces a negative externality of trading for all other market participants. Participants seem to just ignore the externality. Sutter et al. (2016) find that if trade has a negative externality on a third party, volume of trade is reduced but prices in the market depend rather on the relative number of buyers and sellers and not on the existence of a negative externality. Falk and Szech (2013) let participants of their experiment play a double auction and vary the degree of competition by increasing the number of participants in a market. Participants bargain over the live of a mouse and it turns out that they are more willing to sacrifice the mouse if competition is high. Bartling et al. (2014) consider an experimental market where trade leads to a negative externality to a third party. They find that social concerns prevail in a market but decrease in the degree of competition. Bartling et al. (2017) use the same setting and vary the degree of diffusion of the negative externality. They find that such diffusion leaves the level of social concerns almost unaffected. Irlenbusch and Saxler (2015) run an experiment and try to disentangle three characteristics of markets: diffusion of responsibility, social information and market framing. In contrast to Bartling et al. (2017), they find that diffusion of responsibility makes participants rather accept the presence of negative externalities. The same effect is found if transactions are framed as markets. Social information in turn increases social concerns. Reeson and Tisdell (2010) report less contributions to a public good if the game is framed as a market. These studies have considered moral decision making *in* the market, whereas we consider moral decision making *after* market interaction. Such subsequent decision making has also been investigated by other researchers. Brandts and Riedl (2017) compare the effect of favorable and unfavorable experience in a market on the willingness to cooperate in a social dilemma game. They find that cooperation decreases if participants play the social dilemma game with participants from the same market but increases if participants were in a different market before. This suggests that the experience of competing with one another has a negative effect on cooperation. Cappelen et al. (2007) let participants play a dictator game in which they can contribute what they produced before in a production stage where participants can invest and get a return. Compared to the situation when participants were just endowed with some money, they find a significant reduction in the concerns for fairness in the dictator game. Hoffman et al. (1994) find the same effect when framing the pre-dictator-game-stage in terms of a market. Furthermore, giving a price to moral behavior can crowd out intrinsic motivation (e.g. Frey et al., 1996; Frey and Oberholzer-Gee, 1997; Gneezy and Rustichini, 2000; Mellström and Johannesson, 2008; Bowles, 2008). Researchers also find that making people think of money makes them behave more individualistic (e.g. Vohs et al., 2006; Kube et al., 2012).

However, there are also studies that find markets lead to *more* moral behavior in the market. Pigors and Rockenbach (2016) run a lab experiment with consumers who buy a product from a firm that produces at a certain wage paid to its workers. They vary the opaqueness of the production process to the consumers and whether there is competition between firms. It turns out that social responsibility (i.e. caring for the wage of the production workers) only arises if there is supplier competition. Other studies find that markets also lead to more moral behavior in subsequent decisions. In an experimental study with 15 small-scale societies, Henrich et al. (2001) find that there are higher fairness and cooperation in communities with a higher market integration. Buser and Dreber (2014) also find that market priming increases the willingness to cooperate. Furthermore, market priming increases the weight participants give to efficiency and the trust in strangers (Al-Ubaydli et al., 2013).

Hence, there are contradicting results when considering moral decision making in the market *and* in subsequent decisions. One characteristic of the presented studies is that they typically use a concept of preferences over final payoffs in order to define moral behavior. This can be inequality aversion, preferences for efficiency or a Rawlsian motive for helping the least well-off. Together with self-interest, these preferences all belong to a consequentialist view of morality. Most of the literature thus only considers whether the market changes preferences within the consequentialist view, e.g. from other-regarding preferences to self-regarding preferences, without taking into account whether the moral costs of the action itself change. In contrast to that, we explicitly distinguish between the consequences and the moral costs of an action, i.e. between the concepts of consequentialism and deontology. Bartling and Özdemir (2017) and Casal et al. (2016) also distinguish between these concepts. Bartling and Özdemir (2017) investigate the possibility that if one refrains from a selfish action that induces a negative externality, another market actor could step in. From a consequentialist perspective, an action that imposes negative externalities is not immoral if another person would impose the same externality otherwise. However, deontologists would argue that the action itself is immoral. Bartling and Özdemir (2017) find that participants are more likely to take the selfish action if no social norm exists. This suggests that social norms increase the importance of the moral costs of the action. Casal et al. (2016) consider a three-player ultimatum game and find that responders' concerns for negative externalities increase if they are better informed about the externality.

While Bartling and Özdemir (2017) consider moral decision making *in* markets, we contribute to the discussion by investigating whether the experience of interacting in a market influences moral decision making in *subsequent* problems that are unrelated to the market. Our study is thus closely related to Chen (2011), who considers the effect of labor competition on subsequent moral decision making.

In order to derive our hypotheses, we use the preferences of Chen and Schonger (2017), who model deontological preferences as lexicographic. Other economists also model deontological value choices (e.g. Alger and Weibull, 2013; Falk and Tirole, 2016). Stringham (2011) provides an overview of different ways of modeling morals, for example as internal constraints or as preferences (e.g. White, 2004; Rabin, 1995; Zamir and Medina, 2008). Furthermore, he discusses where internal constraints might come from.

As mentioned in the Introduction, several factors have been found to have an impact on moral decision making. Greene et al. (2009) find that spatial distance plays a role. Physical contact between the decision maker and the victim has been considered by Cushman et al. (2006). Sinnott-Armstrong (2008) study the temporal order of events. Costa et al. (2014) show that using a foreign language makes individuals rather respond according to consequentialist principles. The consequences are also relevant for decision making, which corresponds to the theory that some individuals consider both, the consequences and the action. An increasing number of lives that can be saved increases the probability of consequentalist decisions (Bartels, 2008). Furthermore, the relation/closeness to the victims matter (Kurzban et al., 2012). Swann Jr et al. (2010) find that the lives of ingroup members are valued more than the lives of outgroup members. Competition in the labor market right before making a moral decision makes individuals rather decide deontological if they have negative emotions towards the market (Chen, 2011). We add to the discussion of the determinants of moral decision making by investigating the effect of market interaction.

3.3 Design

The study will be conducted on Amazon's Mechanical Turk (MTurk), a labor market intermediary (see e.g. Horton et al., 2011). We implement the experiment with the software o-Tree (Chen et al., 2016). In the first stage, participants are randomly assigned to either a market game (experimental treatment) or a non-market game (control treatment). In the second stage, we confront participants with a moral dilemma in order to elicit their moral preferences. Finally, participants fill in a questionnaire.

After the market/non-market game, we let a sub-sample of the participants do a word completion task, which serves as a manipulation check. Thereby, we verify whether the market game indeed succeeds in shifting participants' mindset towards cost-benefit considerations.

The study is designed to be between-participants in order to rule out potential confounding interaction effects between the various design elements. That means that each participant will only participate in one of the two treatments (either market or non-market). A sufficient number of observations and a proper randomization procedure guarantee causal interpretations.[2]

[2] A power analysis with power 0.9 shows that we need a minimum sample size of 445 participants per treatment to find an effect of 10%-points. We used a baseline share of consequentialist decisions of 37%. This share was found in a pretest on MTurk in which we presented the moral dilemma to 109 participants without previous manipulation.

3.3.1 Market game

"Markets are institutions where sellers and buyers interact and can trade items. Trade occurs whenever a seller and a buyer agree on a price." (Falk and Szech 2013, p.707) Following Falk and Szech (2013) and other researchers, we choose a double auction to represent a market. Double auctions incorporate several typical market aspects such as e.g. the privacy of the own valuation of the good, the interaction and competition among participants and the consideration of costs and benefits of a good. Asks, bids and occurring trades are public information. These auctions are well known for their rapid convergence towards the competitive equilibrium and their high efficiency (Ketcham et al., 1984).

We base the design of the double auction on a computerized version of Smith (1962). 18 participants are assigned to one auction (market) with 9 buyers and 9 sellers of a fictional good and 10 trading rounds. At the beginning of each round, each buyer privately learns his valuation v of the good and each seller learns her production costs c. The valuations are randomly drawn from the set $\{30, 40, 50, \ldots, 110\}$ and the costs are randomly drawn from the set $\{10, 20, 30, \ldots, 90\}$. In the standard double auction, the valuation and costs are the same in each round. In contrast to that, we follow Cason and Friedman (1996) and Kagel (2004) and make a random draw in every round. This should make the market interaction more interesting and more similar among buyers and sellers. In each round, every value from the sets can appear only once among the buyers and sellers. The demand D and supply S at the beginning of each round are thus commonly known and depicted in Figure 3.1. In the competitive equilibrium, the equilibrium price p^* is equal to 60 and there are 5 to 6 trades.

Sellers are told that they can sell one unit of the fictional good in each round. When the market opens, sellers can submit asks, i.e. the price at which they are willing to sell the product. The asks appear in a table labeled "Current bids and asks", which is visible to all market participants. Simultaneously, buyers are told that they can buy one unit of the fictional good in each round. Buyers can submit bids, i.e. the price at which they

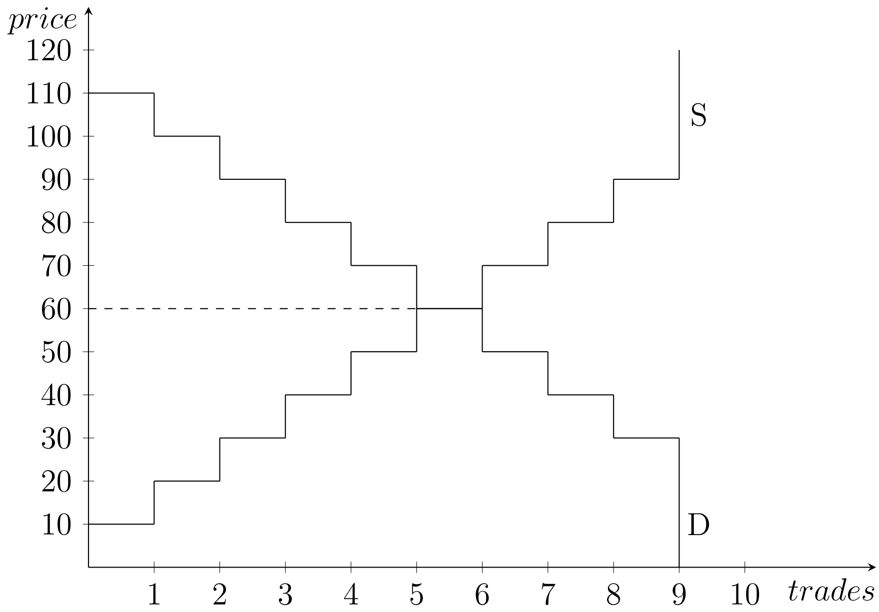

Figure 3.1: Demand and supply in double auction market.

are willing to buy one unit of the good. The bids also appear in the table "Current bids and asks". Figure 3.2 shows the double auction screen for a buyer. A trade occurs if a seller submits an ask that is lower than a current bid in the table or if a buyer submits a bid that is higher than a current ask. The trade is made at the price that was in the table first. Furthermore, a trade occurs if a seller/buyer directly accepts a bid/ask from the table. As long as they did not trade, buyers and sellers can change their bids/asks as many times as they wish until the market closes. If a trade occurs, a buyer's payoff is π_B = valuation - price. A seller's payoff is π_B = price - costs. If no trade occurs, payoffs are zero, i.e. the valuation and production costs only materialize in case of trade. After each trading round, participants receive feedback about their payoff and the trading prices in that round. Each participant takes part in 10 trading rounds. One round is randomly drawn at the end of the experiment to determine the amount that is added to the participant's participation fee.

It is challenging to predict the behavior of participants in a double auction theoretically. However, experimental evidence shows that there is a rapid

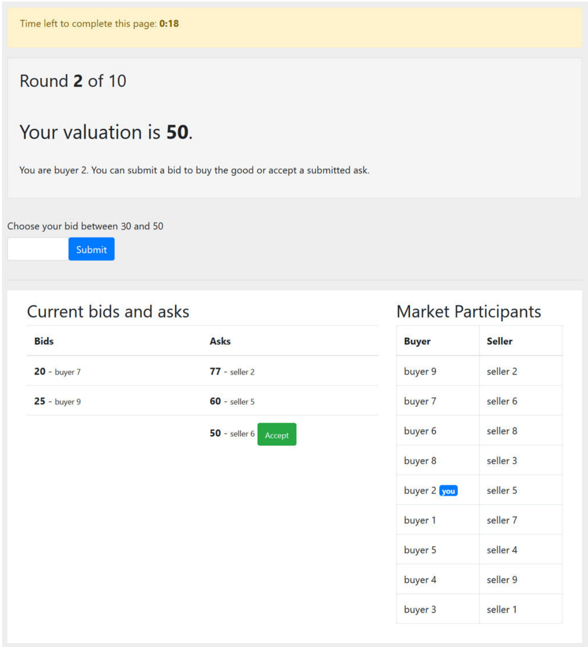

Figure 3.2: Double auction screen for a buyer

convergence towards the competitive equilibrium in the standard version of the double auction with constant valuation and costs over all rounds and unknown distribution (e.g. Smith, 1962). Such rapid convergence has also been found given known distribution of v and c and random draws of valuations and costs in each round (Cason and Friedman, 1996; Kagel, 2004).

A soon as the competitive equilibrium has been reached, we can determine the ex-ante expected payoff per round in equilibrium. In the competitive equilibrium, buyers and sellers with high valuations / low costs for the good end up trading. The expected price is $p^* = 60$. Before learning her production costs, a seller expects to have costs above the equilibrium price with probability $\frac{3}{9}$. She will then expect not to trade and has zero payoff. With probability $\frac{6}{9}$, a seller will have costs lower or equal to the equilibrium price and can sell the good. A seller thus has the ex-ante expected payoff of $\frac{6}{9}E[p^* - c|c \leq 60] = 50/3$. A buyer has the ex-ante probability of $\frac{6}{9}$ that he has a valuation above or equal to the equilibrium price and buys at price p^*. With probability $\frac{3}{9}$, a buyer has a valuation lower than the equilibrium price and does not buy. The expected payoff of a buyer is thus $\frac{6}{9}E[v - p^*|v \geq 60] = 50/3$. The ex-ante expected variance of the payoff in equilibrium amounts to $\frac{3}{9}(0 - \frac{50}{3})^2 + \frac{6}{9}E[(p^* - c - \frac{50}{3})^2|c \leq 60] = \frac{1000}{3}$ for a seller and $\frac{3}{9}(0 - \frac{50}{3})^2 + \frac{6}{9}E[(v - p^* - \frac{50}{3})^2|v \geq 60] = \frac{1000}{3}$ for a buyer.

In the competitive equilibrium, there are at most six trades per round. To give participants sufficient time to decide and trade, each market round lasts 60 seconds[3].

3.3.2 Non-market game

We designed a non-market game which serves as a baseline to the market. The interaction and competition between participants are two crucial aspects of a market setting, as well as the focus on costs and benefit. While these aspects should be ruled out in a non-market setting, we want to keep constant the risk (same expected income and same variance) and the group feeling. Furthermore, the cognitive depletion/load should be similar since it has been found that cognitive load can have an impact on moral judgment (Greene et al., 2008).

We thus let participants play 10 rounds of the following lottery game: Participants are assigned to groups of 9. In each round, participants are asked to guess a number out of the set $L \in \{20, 30, 40, \ldots, 100\}$. Afterwards, a random device allocates every value of the set L to one of the participants in the group. If the guess coincides with the allocated value, the participant receives a winning payoff of $\pi_W = 50$. Otherwise, the losing payoff is

$$\pi_L = \begin{cases} 0 & \text{with prob. } 1/2 \\ 10 & \text{with prob. } 1/8 \\ 20 & \text{with prob. } 1/8 \\ 30 & \text{with prob. } 1/8 \\ 40 & \text{with prob. } 1/8. \end{cases} \tag{1}$$

The expected payoff in each round of the lottery is equal to $E[\pi] = \frac{1}{9} \cdot 50 + \frac{8}{9} \cdot \frac{1}{8}(10 + 20 + 30 + 40) = \frac{50}{3}$, i.e. identical to the ex-ante expected

[3]Plott and Gray (1990) suggest 8 seconds per equilibrium trade as a rule of thumb for the round length in computerized double auctions.

payoff in equilibrium in the market game. The expected variance in each round is equal to $E[(\pi - \frac{50}{3})^2] = \frac{1000}{3}$. The expected payoff and the expected variance of the payoff are thus equivalent in the market and non-market game. Similar to the market game each participant receives feedback about the assigned number and the resulting payoff in that round. At the end of the experiment, one of the 10 rounds is randomly chosen to count for payment.

In this non-market game, participants do not compete or interact. Furthermore, they get a benefit without having to pay anything and they are not confronted with market terminology. However, the lottery incorporates the same risk and should also create a group feeling through the draw of the random number.

Since there is no direct interaction in the lottery, participants play the 10 rounds a lot faster than the 10 rounds of the double auction. In order to keep the depletion as constant as possible, we let participants of the lottery group play a real effort task before they enter the lottery. This real effort task is not incentivized since it has the mere purpose of making depletion similar in the two treatments.

Bartling et al. (2014) use an alternative non-market treatment in which they ask participants to choose a distribution of payoffs between three players. In Falk and Szech (2013)'s non-market condition, participants are asked to decide whether they would prefer to receive CHF 10 or to save the life of a mouse. Both studies try to create a non-market environment where decisions are comparable to the decisions in the market environment. However, it is difficult in our setting to let participants make the same distributional decisions since the double auction results in rather complicated interactions. Furthermore, we do not focus on the decisions *in* but on the decisions *after* the market/non-market interaction.

3.3.3 Manipulation check

Following e.g. Tulving et al. (1982), Bassili and Smith (1986) and Shu et al. (2012), we use a word completion task in order to test whether the market (non-market) game indeed results in a market (non-market) mindset. We constructed the word completion task using the guidelines of Koopman et al. (2013).

We present 14 word fragments in random order to the participants. Nine of these word fragments (MA _ L, CAS _, _ ONEY, _ AX, SUPP _ _, SAL _, BR _ _ CH, _ _ DGET, and SH _ P) can be completed to words related to markets and trade (MALL, CASH, MONEY, TAX, SUPPLY, SALE, BRANCH, BUDGET, and SHOP) or neutral words (as e.g. MAIL, CASE, HONEY, FAX, SUPPER, SALT, BRUNCH, WIDGET, and SHIP). These words were chosen such that without any treatment intervention before, at least 17% of the participants fill in market-related words[4]. If the market interaction indeed manipulates the mindset, participants in the market treatment should be more likely to complete these word fragments with market-related words compared to participants in the non-market treatment. Another set of five word fragments (FR _ _ T, T _ _ LE, BE _ _, BREA _ _, and CAB _ _) with neutral meaning (e.g. FRUIT, TABLE, BEAR, BREACH, and CABLE) is part of the manipulation check to see whether participants in the market treatment and in the non-market treatment complete these word fragments similarly. This allows us to exclude that the market interaction also affects the completion of neutral words. Furthermore, it mitigates the problem that filling in market-related words could also have a priming effect, leading to a higher probability of filling in market-related words in subsequent word fragments.

We interpret a higher share of market-related words in the market treatment as a robustness check for the priming due to the experience of market interaction.

[4]We conducted a pretest on Amazon MTurk with 98 participants to verify this. Koopman et al. (2013) suggest that at least 25% of the participants should fill in market-related words. In our pretest, this was true for most of our market word fragments. Exceptions were MA _ L and SH _ P, where only 17% filled in MALL and SHOP.

3.3.4 Moral dilemma

After the treatment intervention (market or non-market game), we present a moral dilemma to the participants that was first used by Thomson (1985). This moral dilemma has been of interest to many researchers from philosophy (Foot, 1967; Thomson, 1985), neuroscience (Greene et al., 2001; Borg et al., 2006; Ciaramelli et al., 2007), psychology (Cushman et al., 2006; Hauser et al., 2007; Greene et al., 2009) and recently also from economics (e.g. Lanteri et al., 2010; Chen, 2011; Barak-Corren et al., 2018), in order to study moral decision making. The moral dilemma is as follows:

A boxcar breaks loose and is heading toward five workers on the tracks. They do not have enough time to get off the track. However, the participant has the opportunity to save these workers. The participant could use a lever to steer the boxcar to another track where only one worker is working. Many experiments find, that a vast majority of participants would do so. In contrast, most participants remain passive if, in order to save the workers, they have to push a fat man down a platform. These results are very robust (e.g. Petrinovich et al., 1993; Greene et al., 2001; Cushman et al., 2006) and researchers worked a lot on arguing why there are such strong differences between these situations. They argue that two factors are of special importance: physical involvement and the fact that in the push variant, the fat man is used as means to an end. The moral costs of the action are then especially high (Cushman et al., 2006).

In order to get a more balanced distribution of decisions to start with, we use a variant of the train dilemma in which there is a person on a platform above the tracks, standing on a trap door. The participant could open the trap door such that the person would fall down on the tracks, slow down the boxcar and thereby save the lives of three workers. Hence, there is no physical involvement but the person on the platform is used as means to an end. This variant has been used for example by Greene et al. (2009), Schwitzgebel and Cushman (2015) and Everett et al. (2016). They all find that in this moral problem, deontological and consequentialist answers and/or ratings are more balanced than in the lever or the push variant. The trapdoor variant allows eliciting whether people are willing to use others as means to an end without the emotional salience that comes from the physical involvement. The dilemma can be illustrated as in Figure 3.3. Together with the figure,

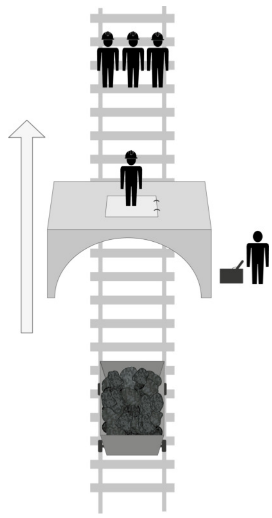

Figure 3.3: Moral Dilemma - Trapdoor

participants are presented the following instructions and have to decide whether to actively intervene or whether to stay passive (the instructions are taken with slight adaptations from Barak-Corren et al. (2018)):

You are working by the train tracks when you see a boxcar filled with coal break loose and speed down the tracks. The boxcar is heading toward three workers who do not have enough time to get off the track. Above the track is a platform with another worker. This worker is not threatened by the boxcar. However, he is standing over a trap door.

You have two options:

Actively intervene: You use a switch that opens the trap door and drops the one worker in front of the boxcar. Thereby, the worker's body gets caught in the wheels of the boxcar and slows it down. As a consequence, the one worker dies and the three workers stay unharmed.

Stay passive: You stay passive and let the boxcar head toward the three workers. As a consequence, the worker over the trap door stays unharmed and the three workers die.

Sidenote: In any case, you are sufficiently protected and stay unharmed. Assume that you will not face any legal consequences for either action.

Now you are asked to take one of the above options. In order to do so, imagine that you find yourself in the previously described situation. Please accept only the information given and try not to introduce additional assumptions that go beyond the problem as stated.

In contrast to many other studies, we ask participants what they would do rather than what they consider to be the morally right thing to do. Several researchers found differences in answers to these two questions (e.g. Kurzban et al., 2012; Tassy et al., 2013; Gold et al., 2013, 2015). We add the question about the morally right decision in the subsequent questionnaire. There is some criticism of the external validity of the hypothetical moral trolley problem. We will discuss this criticism in Section 3.7.

3.3.5 Questionnaire

As the last step, we elicit some socio-demographic data such as gender, age, education, religion, nationality, native language and income. We also ask them to rate their willingness to take risk and their trust in other people. Market and trading experience is elicited by questions about the frequency of trading at eBay or bargaining in markets. As a common procedure in priming studies, we ask whether participants were aware of the purpose of the study, especially of our intention of priming.

We add the questionnaire from Jost et al. (2003) to elicit the participants' attitude towards markets. This measure of fair market ideology was also used by Bartling et al. (2014). Participants have to rate their agreement with 15 statements about the market procedure and the fairness of 10 statements about market outcomes. This allows us to assess possible negative or positive emotions towards markets. Furthermore, we ask participants whether they think they did well in the market/lottery game and we ask them to rate their mood during the experiment. These two questions should capture emotions towards the experience in the experiment. The complete questionnaire can be found in the Appendix.

3.3.6 Procedural details

We plan to conduct the experiment on Amazon Mechanical Turk with a total of 1200 participants. 500 participants will take part in the non-market treatment, 500 participants will take part in the market treatment. 200 additional participants will be presented with the manipulation check directly after the market / non-market game (100 participants per treatment). We use the software oTree (Chen et al., 2016) to program the experiment. We will conduct one treatment with 18 participants per session. We will invite the participants via MTurk. Sessions are expected to last 45 minutes on average. For the market treatment, we need 18 participants to start at the same time. In order to reduce the waiting time for the first arrivers and thus to reduce drop-outs, we will fill the empty spots with automated players ("bots") 10 minutes after the arrival of the first participant. After reading the instructions, participants will be asked to answer some control questions to make sure they understood the rules of the game. Only participants who complete all parts of the experiment receive payment. They will be payed via their MTurk account. Participants' expected earnings are \$5 on average across sessions, with a participation fee of \$3.

3.4 Theory

Chen and Schonger (2017) distinguish between three types of preferences: consequentalist, deontological and consequentialist-deontological preferences. We use their definition of the types.

Definition 1 (Consequentialist preferences)**.** *A preference is consequentialist if there exists a utility representation u such that $u = u(x)$.*

$x = x(d)$ represents the consequences of a decision d. Next to one's own payoff, it also includes e.g. reputation and others' payoffs.

In the moral dilemma described before, an individual with consequentialist preferences would prefer to actively intervene (A) and open the trap door over staying passive (P) if and only if

$$u_1(x_1(A)) \geq u_1(x_1(P)). \tag{2}$$

Assuming that the consequentialist prefers less over many deaths, he would always choose to actively intervene (A).

For a deontologist, preferences are lexicographic. The preferences over decisions depend on the decision d itself. If an individual is indifferent between two decisions, consequences x are considered.

Definition 2 (Deontological preferences)**.** *A preference is called deontological if there exist u, f such that $u = u(d)$, and $f = f(x)$, and for all $(x, d), (x', d')$: $(x, d) \succsim (x', d')$ if and only if $u(d) > u(d')$ or $[u(d) = u(d')$ and $f(x) \geq f(x')]$.*

There is evidence that actively deciding to kill someone rather than letting it happen, is considered as more immoral (Cushman et al., 2006; Moore et al., 2008). Hence, we consider actively intervening as more painful to a deontologist than staying passive:

$$u_2(A) = -M_2(A) < -M_2(P) = u_2(P). \tag{3}$$

where $M_2(d)$ are the moral costs of decision d for a deontologist. A deontologist would thus always choose to stay passive (P) and does not care for the consequences.

There is a third type whose utility function incorporates both: consequences x and the moral costs from decision d.

Definition 3 (Consequentialist-deontological preferences)**.** *A preference is consequentialist-deontological if there exists a utility representation u such that $u = u(x, d)$.*

We consider an additive utility function $u_3(x,d) = x_3(d) - M_3(d)$, where $x_3(d)$ are the consequences and $M_3(d)$ are the moral costs of decision d for the consequentialist-deontological type. Such a type would choose to become active, if and only if the difference in utility from consequences is higher than the difference of moral costs:

$$u_3(A) = x_3(A) - M_3(A) \geq x_3(P) - M_3(P) = u_3(P) \tag{4}$$
$$\Leftrightarrow x_3(A) - x_3(P) \geq M_3(A) - M_3(P).$$

For the consequentialist-deontological type, we again need the assumption that he prefers less over many deaths. He would choose to become active if the improvement in consequences becomes more important than the cost of taking an immoral decision.

A psychological concept used by several economists (e.g. Kőszegi and Rabin, 2006; Bordalo et al., 2013b) suggests that individuals focus on attributes which are more salient. We follow the model of salience-driven preferences of Bordalo et al. (2013b) and assume that individuals indeed give a higher weight to the attribute that has a higher salience.

Changing the weights of consequences and moral costs has no influence on the decision of pure consequentialists and pure deontologists since they only consider one attribute in their decision. However, it has an influence on the decision of consequentialist-deontological types. If consequences are salient, the moral costs are discounted with $\delta \in (0,1]$:

$$u_3(d) = x_3(d) - \delta M_3(d). \tag{5}$$

If the moral costs from the decisions are salient, consequences are discounted with $\delta \in (0,1]$:

$$u_3(d) = \delta x_3(d) - M_3(d). \tag{6}$$

Given consequences are salient, consequentialist-deontological types are more willing to actively intervene:

$$u_3(A) = x_3(A) - \delta M_3(A) \geq x_3(P) - \delta M_3(P) = u_3(P) \tag{7}$$
$$\Leftrightarrow x_3(A) - x_3(P) \geq \delta[M_3(A) - M_3(P)].$$

This condition is more likely to be satisfied than condition (5) and hence we would expect more active interventions if consequences are salient.

There are different theories about what determines the salience of an attribute. Bordalo et al. (2013b) argue that an attribute has a higher salience if it varies more within the choice set. We do not argue against the effect of variation on salience. However, since all participants consider the same moral dilemma, the variation within attributes remains constant between our treatments and should thus not play a role. Researchers from psychology and economics (Benjamin et al., 2010) argue that priming can affect the salience of attributes. Evidence is provided by Benjamin et al. (2010), who use a similar model in order to explain the influence of priming on the choice of individuals. In their model, an individual's utility has two parts: first, they get disutility from choosing another than their individually preferred action. Second, they get disutility from departing from the preferred action of their social category. Benjamin et al. (2010) argue that priming the social category increases the salience of the social category and thus the weight that individuals give to the disutility from deviating from their social category's optimal choice.

3.5 Hypotheses

Our main hypothesis is based on the predictions we get from the preferences of Chen and Schonger (2017) combined with a theory of salience. The hypothesis that the experience of interacting in a market increases the share of individuals who choose to become active corresponds to markets making consequences salient.

Hypothesis 1. *Participants who were exposed to the market environment are more likely to make consequentialist decisions in the moral dilemma than participants who were exposed to the non-market environment.*

As explained before, the theory of priming says that if a concept was used recently, it is more likely to be used in the next decision again. Bowles (1998), Chen (2011) and other economists support the view that markets let consumers focus on the cost-benefit concept and thus on consequences. Following Benjamin et al. (2010), this makes consequences salient in subsequent decisions.

We follow the argumentation of Chen (2011) when we derive the second hypothesis:

Hypothesis 2. *Market interaction leads to more consequentialist decisions if participants have a positive attitude towards markets.*

Chen (2011) argues that the affective state changes moral decision making. When a person has positive associations with something, he rather uses the concept of consequentialism (Valdesolo and DeSteno, 2006) while negative emotions trigger more deontological decisions (Wheatley and Haidt, 2005). We measure the attitude of a participant towards markets with the Fair Market Ideology scale in the questionnaire.

The performance in the treatment game could also have an influence on emotions. This implies the following prediction:

Hypothesis 3. *Better performance in the market/non-market game leads to more consequentialist decisions.*

Bowles (1998) suggests that the effect of market interaction can differ significantly depending on whether a participant performs well or poorly in the market. However, Brandts and Riedl (2017) find that positive experience in the market only has a positive effect on the contributions in a social dilemma if participants did not compete in the same market before.

3.6 Pre-analysis plan

In this section, we first describe the variables and then describe how we will analyze the data and test our hypotheses.

We will exclude the observations of participants who did not correctly answer the moral dilemma comprehension questions in the questionnaire.

Furthermore, we will only consider participants who played at least eight rounds of the market/non-market game[5].

3.6.1 Descriptive analysis

Table 3.1 lists the variables that will be elicited, including their descriptions.

Variable	**Description**
active	Decision dummy: Decision in the moral dilemma: 0 - passive; 1 - active
market	Treatment dummy: 0 - non-market; 1 - market
perform	Average payoff in market/non-market game
mood	Self-reported mood during the experiment: from 1 - very bad to 5 - very good
fmi	Mean of FMI scale (25 items): from -5 to 5
gender	Self-reported gender: 0 - male; 1 - female; 2 - other
age	Self-reported age
income	Self-reported income: 0 - No answer; 1 - Less than \$10,000; 2 - \$10,000 to \$19,999; ... ; 14 - \$100,000 to \$149,999; 15 - \$150,000 or more
education	Self-reported highest completed education: 1 - Less than High School; 2 - High School/GED; 3 - Some College (no degree); 4 - Bachelor's Degree; 5 - Master's Degree; 6 - Advanced Graduate work or Ph.D.; 7 - Other
trust	Self-reported trust attitude: from 0 - "You can't be too careful" to 10 - "Most people can be trusted"

Table 3.1: List of variables.

[5]If a participant closes the browser, a bot takes his place and the game continues. If the participant reopens the browser, he enters the game again.

Variable	Description
risk	Self-reported risk attitude rank: from
	0 - "not at all willing to take risks"
	to 10 - "very willing to take risks"
nation	Self-reported nationality: 1 - US American; 0 - Other
english	Self-reported native language: 1 - English; 0 - Other
religious	Self-reported frequency of attendance of religious services:
	1 - Never; 2 - Once a year; 3 - Once a month; 4 - Once a week;
	5 - Multiple times a week
familiar	Self-reported familiarity with "moral trolley problem" dummy:
	0 - No; 1 - Yes

Table 3.1: List of variables (continued).

We define the variable $perform_i$ as the average payoff across all periods of participant i in the market/non-market game. Furthermore, the variable fmi_i is constructed by participant i's average rating of the 25 items of the fairness market ideology scale. We will also have information about the number of bots in a market, the number of trades per round and the trading prices.

In order to test for successful randomization, we will compare the explanatory variables between the two treatments. More specifically, we will use Fisher's exact tests for gender and Mann-Whitney U test[6] to verify that income, education, and age do not differ significantly between the two treatments.

We will also compare drop-out rates in the treatments with a Mann-Whitney U test. If drop-out rates differ systematically, we have to conclude that there was different attrition in the two treatments.

[6]The parametric alternative of a t-test requires the variable to be interval scaled and to be normally distributed in the population. Throughout the analysis, we will use the t-test instead of the Mann-Whitney U test whenever we can verify that these two requirements are satisfied.

3.6.2 Market game

We are not primarily interested in the behavior of participants in the double auction directly. However, it is still important to look at the price and trading dynamics in order to test whether the markets converge to the competitive equilibrium. If they converge, we can be confident that payoffs in the market and the non-market treatment are distributed approximately equally.

We will use one-sample t-tests to compare the prices and the number of trades in the last trading periods with the equilibrium price of 60 and the equilibrium number of trades between 5 and 6. The coefficient of convergence α of a trading round is the ratio of the standard deviation of prices to the predicted equilibrium price (in percentage). α is thus a measure of exchange price variation relative to the predicted equilibrium exchange price. α is predicted to decline with trading periods. The efficiency of the market is defined as the sum of realized incomes divided by the maximal aggregate income. Efficiency should increase in the number of periods and approximately reach 100%. We will test the predictions of convergence using random effects regressions on a linear time trend with clustered standard errors on market level.

The convergence to the competitive equilibrium is of relevance since we designed the payoffs in the non-market game such that the payoff distributions are equal in expectation. We can also test directly whether the expected payoff of participants is indeed $\frac{50}{3}$ with a one-sample t-test. We expect it to be smaller since the competitive equilibrium is typically only approximated (at least in some periods).

3.6.3 Moral dilemma

In order to test our main hypothesis, we will compare the shares of active and passive decisions in the market and in the non-market treatment. If the randomization works properly, the difference in shares will be caused by the treatment intervention. We will test whether the difference in shares is statistically significant with a Fisher's exact test. We will interpret a significant difference as evidence for our hypothesis that market interaction lets participants rather make decisions according to consequentialism.

We will also compare the shares to the results from the pre-study on MTurk with 109 participants. Without any manipulation before the trap door moral dilemma, we found that 37% of the participants chose to actively intervene.

3.6.4 Regression analysis

We will run logit regressions in order to test our hypotheses more rigorously. We will cluster standard errors on the market/lottery level to account for possible correlation of the error term across participants from the same market or the same lottery. Furthermore, we will include session dummies to account for fixed effects due to dynamics particular to each market session (as for example the number of bots).

The dependent variable $active_i$ is a dummy variable that is 1 if participant i chose to actively intervene in the moral dilemma and 0 if participant i stayed passive. The probability that participant i chooses to actively intervene given X_i is

$$P(active_i = 1|X_i) = \frac{exp(X_i'\beta)}{1 + exp(X_i'\beta)}, \tag{8}$$

where X_i is a vector with all explanatory variables and a constant. The marginal effect of explanatory variable l is

$$\frac{\partial P(active_i = 1|X_i)}{\partial X_{il}} = \beta_l \frac{exp(X_i'\beta)}{1 + exp(X_i'\beta)}. \tag{9}$$

The marginal effect depends on the level of X. We will report marginal effects evaluated at means. When X_{il} is a dummy variable, the marginal effect is defined as

$$P(active_i = 1|X_{il} = 1, X_i) - P(active_i = 1|X_{il} = 0, X_i). \tag{10}$$

We will run logit regressions, where we add additional explanatory variables step by step. In the first logit regression, X_i will consist solely of the market dummy $market_i$. In a second step, we want to test the hypothesis that the attitude towards markets moderates the effect of market interaction. Controlling for such moderator variables is especially important if the effect goes in opposite directions. We will add the fairness market ideology measure fmi_i and an interaction variable $fmi_i\#market_i$. The interaction variable captures the effect of market attitude given a participant was assigned to the market treatment. Our hypothesis 2 suggests that $fmi_i\#market_i$ has a positive effect on the probability of actively intervening.

Since the argument that negative/positive emotions affect moral decision making also holds for participants in the non-market treatment, we will run a third logit regression and add the variables $mood_i$ and $perform_i$ and their interactions with $market_i$ to the explanatory variables. These variables capture the self-reported mood during the experiment and the performance of the participant in the market/non-market game. We will interpret positive coefficients for these variables as further evidence for our hypothesis 3.

Finally, we estimate the model including the control variables gender, age, religion, nationality, native language, income, employment, trust, risk aversion and market experience.

3.6.5 Manipulation check

The manipulation check serves as a robustness check for the priming of participants. Each participant could maximally fill in 9 market-related words out of 14 words in total. We will construct a market-priming-score which is computed simply by the number of completed market-related words (hence from 0 to 9). Afterwards, we will compare the average number of individual scores between treatments. In addition, we compare both mean scores with our baseline mean score from the pretest without manipulation stage.

In the baseline study with 98 participants and no priming, we found a mean score of 3.49. We will test for the significance of the differences with a Mann-Whitney U test. We expect that the mean score in the non-market treatment does not significantly differ from the baseline, whereas the mean score in the market treatment is significantly higher than both other mean scores.

3.7 Limitations

The attempt to prime participants through experimental games is a new method and is different from previous approaches[7]. We are aware of the fact that by explaining the double auction, several market-related words are pinned in the recognition memory and make it easier to be recognized in the manipulation check. We counter this effect by using only market-related words which were not used in the instructions or appeared in the instructions of both treatments.

Cohn and Maréchal (2016) raise some other worries when it comes to priming. First, several priming studies could not be replicated (Yong, 2012). Second, there is doubt on whether priming really works through the proposed mechanism. They suggest mitigating the latter by using a manipulation check, which we will implement with the word completion task. The problem of replication can be reduced by the provision of all material necessary for replication.

Another possible confounding factor is that cognitive depletion might have an influence on moral decisions (Greene et al., 2008). The transcription task and the lottery might not cause the same cognitive depletion as the double auction and this could result in different decisions. However, one could argue that cognitive depletion is also present in a real market and is thus illustrated realistically by the experimental double auction.

Several studies question the external validity of the moral trolley problem because of its hypothetical nature (FeldmanHall et al., 2012; Bauman et al., 2014; Gold et al., 2015). Bauman et al. (2014) revisit the external validity of moral trolley problems, observing that 1) participants are often amused, 2) trolley problems differ from moral problems which are encountered in reality and 3) that they elicit different psychological processes than real-world situations. Several researchers try to make the moral problems more realistic. Gold et al. (2013) and Gold et al. (2015) introduce trolley problems with

[7]In one study e.g., participants had to arrange words to form a proper sentence. In one condition the available words were neutral, in the other related to markets and trade (see Al-Ubaydli et al. 2013).

economic incentives and real-life consequences. While harm in the traditional moral trolley problem is typically deaths, they generalize the problem to economic harm. They find that the difference in moral judgments between the lever and the push scenario remains high. Navarrete et al. (2012) let participants play the lever scenario in a virtual reality environment and find that 90.5% of the participants turn the trolley. This result is in line with the 90% typically found in the classic hypothetical moral trolley dilemma.

With our setting, we cannot make inferences about the long-run effect of priming by market interactions. It would be interesting for further research to investigate long-lasting effects by letting participants take moral decisions repeatedly over time or by letting more time pass before presenting them with the moral decision.

We will use the online labor market MTurk. Benefits are that experiments are easy to implement and data can be generated at a low hourly pay of the participants. Drawbacks are that the researcher cannot control for the environment in which the participants are, whether they pay attention and that participants are mainly from the US. However, Berinsky et al. (2012) examine experimental data generated by Mechanical Turk users and find that results are comparable to data generated in a common laboratory. This is also reflected by numerous publications using Mechanical Turk data (e.g. Ambuehl et al., 2015; Chandler and Kapelner, 2013; Dreber et al., 2013).

Real-time interaction has not been tried often on MTurk yet. A recent paper by Arechar et al. (2018) discusses the methodological challenges. They find that in spite of all the problems, results from a public goods game are similar to the results in the laboratory. One problem of real-time interaction is the drop-out of participants. In our double auction, 18 participants have to be present at the same time in MTurk. We program bots which will take over in case some participants drop out. These bots will make bids/asks equal to their valuation/costs at a random point in time within a fixed (and commonly known) time-frame. The bots will be indicated as such, so that participants know whether they are playing with bots or real persons. However, our main question is not about the behavior in the double auction and we expect that the introduction of bots does not influence the experience of interacting in a market.

Instead of using a general subject pool, we could also test whether market professionals are more consequentialist than non-professionals. However, we would have to encounter the problem of self-selection. Furthermore, running an online experiment in a non-field setting gives us more control over the decision environment and the treatment intervention. Additionally, more and more people all over the world gain access to markets and engage in some form of market interactions. Understanding the influence of market interaction on moral decision making is therefore especially important for a general, representative subject pool.

3.8 Conclusion

In this paper, we presented an experimental design to test the hypothesis that market interaction leads to more consequentialist decisions in a subsequent moral dilemma. The design also allows detecting possible moderator effects of positive/negative emotions towards markets. Furthermore, the results of the experiment will give some insights on whether it is possible to prime participants, i.e. to change their mindsets, by letting them play an experimental game. This would have implications for experimental research in general.

If market interaction indeed increases the weight that individuals give to consequences, implications for general decision making depend on the preferences over consequences. If individuals only care for their own payoff, giving a higher weight to consequences makes them more likely to engage in individually profitable actions, even if these actions contradict moral norms as e.g. imposing negative externalities, lying or not cooperating. If individuals also care for the payoff of others, it might not necessarily be the case that more immoral actions are taken. On the one hand, there are less concerns for taking immoral actions. On the other hand, individuals might try to avoid actions that have inefficient consequences.

It is possible that the experience of market interaction also has an effect on other variables that are elicited in the questionnaire. For example, Al-Ubaydli et al. (2013) would suggest that trust in other people is increased by market interaction and Francois et al. (2009) show that higher market competition leads to higher trust.

Future research should concentrate on the effect of market interaction on other moral dilemmas, e.g. whether participants are willing to lie in order to improve consequences. Specifically, we could give one person the opportunity to lie which increases his/her monetary payoff and the payoffs of all players of his/her group (Erat and Gneezy, 2012). We would expect that the salience of consequences increases the probability that a person is willing to lie. This extends our study with a consequential/deontological choice to an economically incentivized setting. Alternatively, the moral dilemma could be made more realistic and incentivized non-economically, e.g. by physical pain through electrical shocks. Instead of the hypothetical decisions on the lives of workers, participants could be confronted with the decision whether they let three other participants receive an electrical shock or whether they actively decide that an outsider is shocked instead.

3.9 Appendix

3.9.1 Instructions Double Auction

Welcome and thank you for your participation!

This is a study of decision-making. Please read the following instructions carefully.
The study consists of 3 parts:

- Part 1: An interactive game
- Part 2: A decision scenario
- Part 3: A short questionnaire

We will explain each part of the study before the respective part will start. You will receive a fixed participation reward of \$3.00 at the end of part 3. In part 1, you can earn additional points which will be converted to real money.

One point equals \$0.20.

The money you will earn in part 1 will be added to the fixed participation reward of \$3.00. In parts 2 and 3, no additional money can be earned. You must finish all 3 parts of the study to receive payment. You will receive a personal code that allows you to receive your payment through MTurk at the end of the study.

General rules

In this part, you will be interacting in an online market consisting of 9 buyers and 9 sellers. These are real people interacting in real-time. You will be randomly assigned to the role of a buyer or the role of a seller. You will keep this role throughout the entire duration of the game. You will learn your role after reading the instructions.

There will be 10 trading rounds in which you can earn points by trading. One of these 10 rounds will be randomly chosen at the end of the study to count for your payment. In each of the 10 trading rounds, the market opens for 60 seconds, during which trading between buyers and sellers is possible.

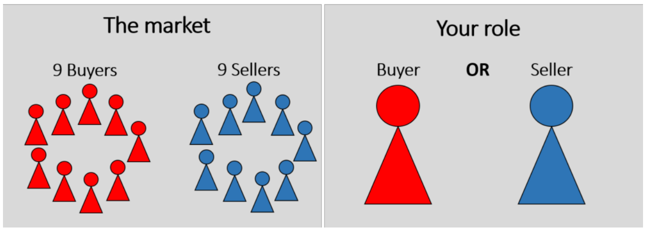

Figure 3.4: Market with buyers and sellers

What can a buyer do?

In each trading round, each buyer can buy one unit of a fictional good. By buying and hence owning this good, buyers receive a benefit in terms of a valuation. At the beginning of each trading round, each buyer learns how much the good is worth to him, i.e. he learns his own valuation. These valuations are different for each buyer and measured in points. The valuations will be randomly assigned to the buyers in each round and can be 30, 40, 50, 60, 70, 80, 90, 100 or 110 points. Among the buyers, each number is assigned only once within a round, i.e. one buyer is assigned a valuation of 30 points, another buyer is assigned a valuation of 40 points, yet another buyer is assigned a valuation of 50 points and so on.

What can a buyer earn?

A buyer can earn points by trading, i.e. by buying the good from a seller. If a trade occurs, a buyer gets the valuation (measured in points) minus the price (measured in points):

Buyer's earnings in points = valuation - price

If no trade occurs, a buyer earns 0 points.

How does trading work for the buyer?

Trading is done on an online market platform. A buyer can trade in *two possible ways*:

1. He can accept an ask that has been submitted by a seller. The trade then occurs at the price of the ask.
2. Alternatively, he can submit a bid, i.e. the price at which he is willing to buy. If a seller accepts this bid or submits a lower ask, the trade occurs at the price of this bid.

The two possible ways of trading will be explained in more detail later on the screen.

The following screenshot shows what the online market platform looks like:

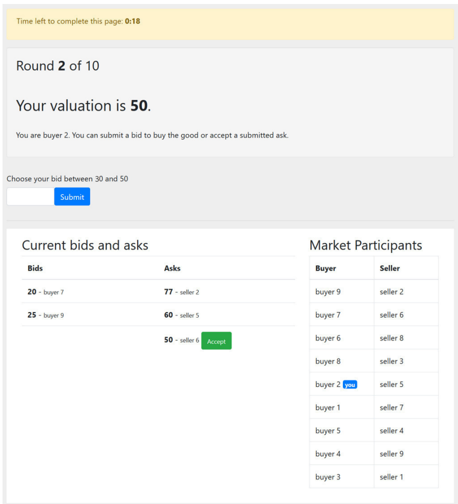

Figure 3.5: Double Auction Screen Buyer

In each trading round, buyers are numbered consecutively from 1 to 9. The numbers change each round such that no buyer can be identified. In the example, the buyer has number 2. The valuation of the buyer in this round is 50, as you learn from the message on the screen “Your valuation is 50.”

You see a list of all market participants at the right side of the screen. Bids and asks of the buyers and sellers are displayed in the table "Current bids and asks".

At the beginning of each round, there is a countdown of 10 seconds during which each buyer learns his valuation. Then the market opens for 60 seconds. While the market is open, each buyer can trade one unit of the good by accepting an ask of a seller or by submitting a bid (these are the two possible ways of trading shortly described before):

1. **Each buyer can accept an ask** from the table "Current bids and asks". He does so by clicking on the *accept* button that shows up next to the lowest ask in the table. The good then trades for the price of the ask.

2. **Alternatively, each buyer can submit a bid**, i.e. a price at which he is willing to buy the good. In order to do so, he can enter a value and click on *Submit*. The bid then appears in the table "Current bids and asks" and is visible to all sellers and buyers. Within a trading round, a buyer can revise his bid as many times as he likes and replace it by a new one. If a seller accepts the bid of the buyer, trade occurs at the price of the bid. To avoid a loss, a buyer can only submit bids that are equal to or lower than his valuation.

   If a buyer submits a bid and there are lower asks in the table, trade occurs at the price of the lowest ask. In principle, it is the same as if the buyer had directly accepted the lowest (and thus currently best) ask in the table.

When the market closes, each buyer receives feedback about his payoff and all trades from that round.

What can a seller do?

In each trading round, each seller can produce one unit of a fictional good that he can sell in the market. At the beginning of each trading round, each seller learns how much it costs for him to produce this good, i.e. he learns his own production costs. These production costs are measured in points. They will be randomly assigned to the sellers in each round and can be 10, 20, 30, 40, 50, 60, 70, 80 or 90 points. Among the sellers, each number is assigned only once within a round, i.e. one seller is assigned production costs of 10 points, another seller is assigned production costs of 20 points, yet another seller is assigned production costs of 30 points and so on.

What can a seller earn?

A seller can earn points by trading, i.e. by selling the good to a buyer. If a trade occurs, a seller gets the price (measured in points) minus the production costs (measured in points):

Seller's earnings in points = price - production costs

If no trade occurs, the good is not produced, i.e. the seller does not pay the production costs. Thus, if no trade occurs, a seller earns 0 points.

How does trading work for the seller?

Trading is done on an online market platform. A seller can trade in *two possible ways*:

1. He can accept a bid that has been submitted by a buyer. The trade then occurs at the price of this bid.

2. Alternatively, he can submit an ask, i.e. the price at which he is willing to sell. If a buyer accepts this ask or submits a higher bid, the trade occurs at the price of this ask.

The two possible ways of trading will be explained in more detail later on the screen.

The following screenshot shows what the online market platform looks like.

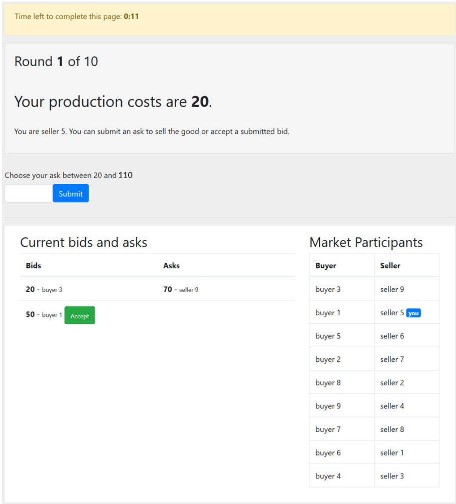

Figure 3.6: Double Auction Screen Seller

In each trading round, sellers are numbered consecutively from 1 to 9. The numbers change each round such that no seller can be identified. In the example, the seller has number 5. The production costs of the seller in this round are 20, as you can see from the message on the screen "Your production costs are 20." You see a list of all market participants at the right side of the screen. Bids and asks of the buyers and sellers are displayed in the table "Current bids and asks".

At the beginning of each round, there is a countdown of 10 seconds during which each seller learns his production costs. Then the market opens for 60 seconds. While the market is open, each seller can trade one unit of the good by accepting a bid of a buyer or by submitting an ask:

1. Each seller can accept a bid from the table "Current bids and asks". He does so by clicking on the *accept* button that shows up next to the highest bid in the table. The good trades at the price of the bid.

2. Alternatively, each seller can submit an ask, i.e. a price at which he is willing to sell the good. In order to do so, he can enter a value and click on *Submit*. The ask then appears in the table "Current bids and

asks" and is visible to all sellers and buyers. Within a trading round, a seller can revise his ask as many times as he likes and replace it by a new one. If a buyer accepts the ask of the seller, trade occurs at the price of the ask. To avoid a loss, a seller can only submit asks that are equal to or above his production costs.

If a seller submits an ask and there are higher bids in the table, trade occurs at the price of the highest bid. In principle, it is the same as if the seller had directly accepted the highest bid in the table.

When the market closes, each seller receives feedback about his payoff and all trades from that round.

Control questions

Please answer the following questions:

1. You are a buyer. Your valuation for the good is 50 points. You submit a bid of 40 points and a seller accepts this bid. What are your earnings (in points)?

2. You are a seller. Your production costs for the good are 20 points. You submit an ask of 25 points and a buyer accepts this ask. What are your earnings (in points)?

3. You are a buyer. Your valuation for the good is 40 points. Is it possible to submit a bid of 60 points? Yes/No

What comes next

- If you click on the next button, you will enter a waiting screen. Please be patient and wait until everyone finished reading the instructions and answering the questions. You will have to wait for 10 minutes at maximum.

- Afterwards, you will learn your role: Seller or buyer.

- There will be two test trading rounds to make you familiar with the screen and the rules. The earnings from the test rounds do not count for payment.

- After the two test rounds, there will be 10 trading rounds.

- Remember: **One** out of the 10 trading rounds will be randomly chosen at the end of part 3 to count for payment. The chosen round determines the money that will be added to your participation reward of $3.00. One point equals $0.20. You will learn which round was chosen and the money you earned after finishing part 3.

- Due to technical problems or other reasons it can happen that participants drop out of the study. To carry on with the game, automated players will take the open spots. Such a “bot” will always offer the good at a price equal to his production costs as a seller and bid a price equal to his valuation as a buyer. Bots will be indicated as such. (Therefore, all other players are real human players.)

3.9.2 Instructions Lottery

Welcome and thank you for your participation!

This is a study on decision-making. Please read the following instructions carefully.
The study consists of 3 parts:

- Part 1: A task + a game

- Part 2: A decision scenario

- Part 3: A short questionnaire

We will explain each part of the study before the respective part will start.

You will receive a fixed participation reward of \$3.00 at the end of part 3. In part 1, you can additionally earn points which will be converted to real money.

One point equals \$0.20.

The money you will earn in part 1 will be added to the fixed participation reward of \$3.00. In parts 2 and 3, no additional money can be earned. You have to finish all 3 parts of the study to receive payment. You will receive your personal code that allows you to receive your payment through MTurk at the end of the study.

General rules

This part consists of two sections. First, we will ask you to spend 10 minutes on a **transcription task**. Second, you will play a **lottery game** in which you can earn points. For the lottery, you will be randomly assigned to a group of 9 participants. The other participants are real people (MTurkers). Within this group, each participant plays 10 rounds of the lottery game, which we will explain to you later. One of these rounds will be randomly chosen at the end of the study to count for your payment.

How does the transcription task work?

You will see some text passages and we ask you to transcribe (copy) these passages into an input field. Try to be exact and make sure to get all characters and spaces correctly. Note that copy-paste is not possible. Your earnings do not depend on your performance. However, we ask you to transcribe as many words as possible within the 10 minutes. After the transcription task, you are assigned to a group of 9 participants and the lottery will start.

How does the lottery work?

At the beginning of each round, each participant has to choose a number that can be 20, 30, 40, 50, 60, 70, 80, 90 or 100 and enter this number in an input field on the screen.

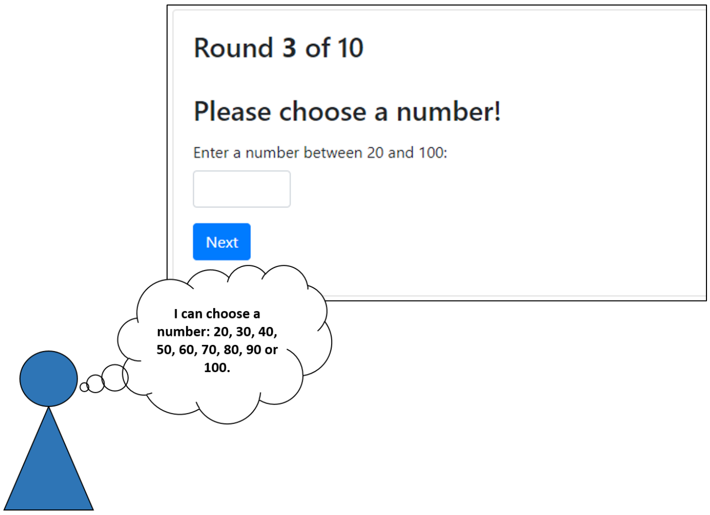

Figure 3.7: Lottery Screen

Then, the computer randomly assigns a number that can be 20, 30, 40, 50, 60, 70, 80, 90 or 100 to each participant. Among the 9 participants of a group, each number is assigned only once within a period, i.e. one participant is assigned number 20, another participant is assigned number 30, yet another participant is assigned number 40 and so on.

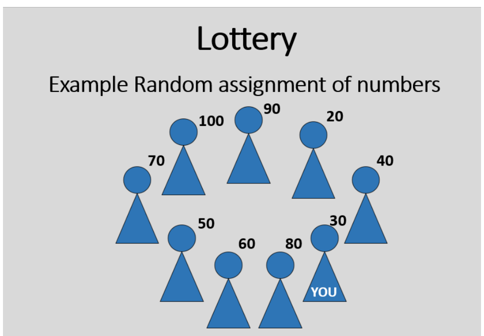

Figure 3.8: Lottery Group

What can a participant earn?

Case 1: Number chosen = number assigned by computer
If the number a participant chooses coincides with the number that was randomly assigned to him, this participant earns 50 points.

Case 2: Number chosen ≠ number assigned by computer
If the number a participant chooses does not coincide with the number that was randomly assigned to him, this participant earns:

- 0 points with probability 50%
- 10 points with probability 12.5%
- 20 points with probability 12.5%
- 30 points with probability 12.5% or
- 40 points with probability 12.5%.

Note: The earnings of one participant are independent of all other participants' earnings.

Example 1
If a participant chooses number 20 and is then assigned number 80, he receives:

- 0 points with probability 50%
- 10 points with probability 12.5%
- 20 points with probability 12.5%
- 30 points with probability 12.5% or
- 40 points with probability 12.5%.

Example 2
If a participant chooses number 70 and is then assigned number 70, he receives 50 points.

Control questions

Please answer the following questions to make sure you understood the rules of the game correctly.

1. You choose number 60. The computer randomly assigns number 40 to you. Your earnings are then 50 points. Yes/No
2. You choose number 20. The computer randomly assigns number 20 to you. What are your earnings (in points)?
3. If you are assigned number 80, can another participant be assigned number 80? Yes/No

What comes next

- If you click on the next button, you will directly continue with the transcription task.
- Once you finished the transcription task, you will proceed with the lottery: There will be two test rounds of the lottery to make you familiar with the screen and the rules. The earnings from the test rounds do not count for payment.
- After the test rounds, there will be 10 rounds of the lottery.
- Remember: **One** out of the 10 rounds will be randomly chosen at the end of part 3 to count for payment. The chosen round determines the money that will be added to your participation reward of $3.00. One point equals $0.20. You will learn which round was chosen and the money you earned after finishing part 3.

3.9.3 Questionnaire

1. Moral Dilemma Questions

   (a) Please, explain based on what you made your decision in the boxcar situation. *Text field*

   (b) Please remember the boxcar situation: How many persons would be killed if you stayed passive? *Text field, only numbers possible.*

   (c) Please remember the boxcar situation: How many persons would be killed if you actively intervened? *Text field, only numbers possible.*

   (d) I seriously thought about my decision. *7-point scale from strongly disagree to strongly agree*

   (e) I am satisfied with my decision. *7-point scale from strongly disagree to strongly agree*

   (f) Which of the actions is the morally right one? *Stay passive, actively intervene, neither, both (in random order)*

   (g) In your opinion, how did you perform in the game before? *Very poorly, poorly, fairly, well, very well*

   (h) How was your mood during the study? *5-point scale from very bad to very good*

2. Experiences in/with markets

   (a) Do you negotiate prices of products you want to buy? *Never, rarely, sometimes, often, always*

   (b) Do you use online shopping platforms like e.g. Ebay (as buyer or seller)? *Never, rarely, sometimes, often, always*

   (c) Do you trade in the stock exchange market? *Never, rarely, sometimes, often, always*

3. Fair Market Ideology (FMI) Scale

   Please evaluate the following statements on the 11-point scale ranging from -5 ("Completely disagree") to +5 ("Completely agree"):

   (a) The free market system is a fair system.
   (b) Common or "normal" business practices must be fair, or they would not survive.
   (c) In many markets, there is no such thing as a true "fair" market price.
   (d) Ethical businesses are not as profitable as unethical businesses.
   (e) The most fair economic system is a market system in which everyone is allowed to independently pursue their own economic interests.
   (f) Acting in response to market forces is not always a fair way to conduct business.
   (g) The free market system is an efficient system.
   (h) The free market system has nothing to do with fairness.
   (i) Acting in response to market forces is an ethical way to conduct business.
   (j) In free market systems, people tend to get the outcomes that they deserve.
   (k) The fairest outcomes result from transactions in which the buyers pay the "fair" market price.
   (l) Profitable businesses tend to be more morally responsible than unprofitable businesses.
   (m) Regulated trade is fair trade.
   (n) Economic markets do not fairly reward people.
   (o) Whatever price a buyer and seller agree to trade at is a fair price.

Please evaluate the following statements on the 11-point scale ranging from -5 ("Completely unfair") to +5 ("Completely fair"):

(a) When a company raises the prices that it charges its customers for its goods, because management has obtained market research which suggests that its customers are willing to pay more, it is...

(b) When a professional athlete receives a raise because a raise has been received by another league player of comparable ability, but none the other team members receive comparable raises, it is...

(c) The fact that scarce goods tend to cost more in a free market system is...

(d) When a company downsizes in order to reduce its costs to be more competitive with rival companies, it is...

(e) When concessions at airports and concerts charge higher prices for beverages because they know that their customers have no alternatives, it is...

(f) The fact that wealthier people live in bigger homes and better neighborhoods than poorer people who cannot afford to pay the same prices is...

(g) When a company lays off higher-cost employees in the U.S. and replaces them with lower wage workers in a foreign country in order to make higher profits, it is...

(h) The fact that housing prices in Palo Alto, California are four to six times those for comparable houses in Chicago is...

(i) The fact that more educated employees tend to earn higher wages than less-educated employees is...

(j) The fact that some working families can afford to hire more household help than others is...

4. Risk Aversion

How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please tick a box on the scale, where the value 0 means: "not at all willing to take risks" and the value 10 means: "very willing to take risks".

5. Trust

   Generally speaking would you say that most people can be trusted or that you need to be very careful in dealing with people? Please tick a box on the scale, where the value 0 means: "You can't be too careful" and the value 10 means: "Most people can be trusted".

6. Sociodemographic variables

   (a) Please tell us with which gender you identify yourself. *Male, Female, Other (with text field)*

   (b) Please tell us your age. *Text field, only numbers*

   (c) What is your native language? *English, Other (with text field)*

   (d) What is your nationality? *US American, Other (with text field)*

   (e) Would you please give your best guess on your annual income of the previous year? Please indicate the answer that includes your entire household income before taxes. *12 Categories in steps of 10,000: Less than $10,000; $10,000 to $19,999;...; $100,000 to $149,999; $150,000 or more*

   (f) What is your highest level of education you completed? *Less than High School, High School/GED, Some College (no degree), Bachelor's Degree, Master's Degree, Advanced Graduate work or Ph.D., Other (with text field)*

   (g) What is current employment status? *Employed for wages, Self-employed, out of work and looking for work, out of work but not currently looking for work, a homemaker, a student, military, retired, unable to work, Other (with text field)*

   (h) What religion do you associate yourself with? *Christian, Jewish, Muslim, Hindu, Buddhist, Atheist, Other (please specify) Text field*

(i) How often do you attend religious services? (Answers may be approximate.) *Never, Once a year, Once a month, Once a week, Multiple times a week*

(j) Are you familiar with any version of the so-called "Moral Trolley Problem" or "Trolley Problem"? *Yes, No*

(k) If you wish you can leave us a comment. *Text field*

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Ich erkläre hiermit, dass ich diese Arbeit selbständig verfasst und keine anderen als die angegebenen Hilfsmittel benutzt habe. Alle Koautorenschaften sowie alle Stellen, die wörtlich oder sinngemäss aus Quellen entnommen wurden, habe ich als solche gekennzeichnet. Mir ist bekannt, dass andernfalls der Senat, gemäss Artikel 36 Absatz 1 Buchstabe o des Gesetzs vom 5. September 1996 über die Universität, zum Entzug des aufgrund dieser Arbeit verliehenen Titels berechtigt ist.

Bern, 1. Juni 2018

N. Adrian

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