Essays in Industrial and Political Economics

Dissertation

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Contents

Chapter 1

Introduction

The connections and interactions of people form the basis of any interesting topic for economic research. The "interaction" most representative of economic research, and in my view the heart of economics as such, is competition. The etymology of competition comes from "com", meaning together, and "petere", meaning to strive or to seek. Thus, to compete comes from "strive together" or to "meet and come together". This thesis analyses three competitive situations, i.e., interactions of individuals who meet and come together and strive towards a similar goal. How political parties structure their internal competition, how consumers process information and make their consumption decisions, how firms disclose their product information and operate in connected, i.e., primary and secondary, markets are just some of the questions that will be addressed in the following pages.

In all chapters of this thesis, I highlight a competition between individuals, a group of individuals or another economic entity such as a firm, commonly referred to as players of the competition. The outcome of the competition analyzed always depends on the actions and the information possessed by the players. To analyze the competition in depth, the actions and information of each player are captured in a game theoretic model. In other words, Game Theory serves as a language that allows me to explain the outcome and to outline different arguments about possible drawbacks, peculiarities and benefits of the competitive situation.

Economists and mathematicians in the 20th century were already interested in analyzing and explaining economic behaviour by building formal mathematical models. Three famous economists who devoted much of their careers to such models, are John Harsanyi, John Nash and Reinhard Selten. The method used and refined by these economists is called Game Theory. In 1994, they were jointly awarded the "Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel" for their pioneering and groundbreaking work on Game Theory. Later on, psychologists and economists such as Daniel Kahnemann and Vernon Smith took the sketched models and applied them to reality. This was the fruitful ground for behavioural microeconomics.

The aim of the game theoretic models, developed by scholars such as Reinhard Selten, is to describe how decisions of (boundedly rational) individuals are reached. In other words, the application of Game Theory allows to map any real-world situation into a formal model and then to analyze that model. Experimental economists and psychologists may then conduct experiments to validate and explore (bounded rational) behaviour. Economic experiments thus help to evaluate the empirical relevance of game theoretic models and subsequently to refine them. In general, the economic scientific community has sought to develop models and define concepts to explain a wide range of phenomena. Take for example the concept named after John Nash, the Nash equilibrium, which is one of the key concepts applied in the majority of economic theory. The Nash equilibrium applies to the most broadest range of topics by defining the best response that an individual can make, given the actions of every other interacting individual. Thus, in a Nash equilibrium no individual has an incentive to deviate from her actions. This concept is an essential part of Game Theory and is widely studied in economic experiments.

In this thesis, I use Game Theory and apply it to topics in the political and industrial arena. In addition, I apply findings of recent economic experiments as well as the empirical literature to refine the models outlined. Parts of the thesis depart from the assumption of fully rational individuals and assume bounded rational behaviour. In particular, chapters three and four belong to the research strand of behavioural economics. In contrast to standard economic research, these chapters assume that consumers do not necessarily process relevant information rationally. Consumers may be uninformed, systematically paying no attention towards some information, fail to understand information, use heuristics or engage in other non-rational behaviour (for an overview see Gabaix 2019). These modelling assumption therefore limit the models applicability, but aim to make the model more relevant to realistic consumer behaviour.

Finally, this thesis is largely concerned with analyzing competitive situations in our everyday lives. My understanding of doing research always draws from specific experiences of the daily live. Such experiences start with voting in a general election, reading about political competition in the newspaper, shopping groceries in a supermarket or visiting online market sites. Each of these situations contains a competitive aspect, that can be analyzed by applying economic theory. In this way, the models outlined take into account the peculiarities of each situation. Of course, the matter of all three chapters can be partly transferred and reinterpreted to similar competitive situations. However, unlike other economic research, the following chapters are of an applied economic nature.

The second chapter concerns the small but growing sub-field of Contest Theory, i.e., Game Theory applied to contests. The key question addressed here is the optimal design of a primary, i.e., the competition within a political party. The third chapter looks at firms' decision to disclose relevant product information or to remain silent when consumers are not perfectly rational, e.g., when they are inattentive. In the last chapter, I analyze the broader picture of the links between secondary (used) and primary (new) markets. All topics cover competition between economic agents; whether in a contest (chapter 2), a seller-buyer relationship (chapter 3) or the broader perspective of multiple economic agents buying and selling products across different markets (chapter 4). In the second chapter, the individuals' degree of rationality plays a minor role, i.e., individuals are assumed to be perfectly rational. In the remaining chapters three and four, the traditional modeling is extended by behavioural assumptions.

The chapter "Party Politics - A Contest Perspective" analyzes the realm of competition within and between political parties. In particular, the chapter covers the design of the inner competition of parties and its implication for the subsequent competition between parties, such as in a general election. We analyze the optimal primary design in order for a party to maximize the probability of winning the general election. The most popular example for an intra-party competition are the primary elections in the United States.[1] All major newspapers highlight the intense process of the US primaries, which strongly influence the later general election. The question addressed in the chapter deals with the optimal design and use of resources across those two contests. For example, in the 2020 US Democratic primary, all candidates together spend approximately $1.2 billion (Evers-Hillstrom 2020). Of course, these resources may also be useful for competing in the general election. We highlight the dependency of a party's decision to spend its resources on its primary competition and the quality of the primary's candidates and explain why parties may limit the extend of their intra-party competition.

The chapter "Unaware Consumers and Disclosure of Deficiencies" analyzes firms' decision to disclose relevant information about products. The starting point of this project was the decision of the German federal government to make the nutritional labeling of grocery products voluntary. We analyze the argument that competition between firms will incentivize firms to disclose their product information voluntarily (see for example Milgrom 2008). In contrast to the existing economic literature, we depart from the assumption that all consumers perfectly understand the consequences of firms' actions, i.e., information provision, and argue that consumers may be unaware of relevant product attributes (unaware and aware consumer types) or may be unable to understand relevant information (amateur and expert consumer types). We show that if consumers depart from being perfectly rational, firms may remain silent. In addition, we discuss relevant policy instruments such as implementing a minimum standard. Recent examples, such as the implementation of mandatory labelling of electronic goods, e.g., for the energy consumption of washing machines or houses, highlight the relevancy of this topic.

The last chapter "Secondary Markets Revisited" analyzes the link between primary and secondary markets and focuses on the role of platforms connecting these markets as well as making consumers aware about the existence of secondary markets. The emergence of virtual platforms providing enhanced access to secondary markets as well as the development of firms operating their own secondary market is one of the key aspects of this chapter. Similar to the previous chapter, I assume that consumers may not be aware of secondary markets and thus disregard the resale value of a newly bought product. However, platforms maximize their profit by making consumers aware of the resale value, which leads to an increased trading volume across markets. The recent trend for consumers to buy second-hand rather than new items and to use online platforms lies at the heart of this research.

All the chapters are of an applied theoretical nature. In order to extend the research presented, evaluate and adjust the proposed models, future research can translate the questions posed into an empirical framework or experimental setting. Both economic theory and applied theory can thus be an important part of achieving a better understanding of the competition in our daily lives.

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[1]Other political parties in democracies such as Great Britain, Italy or Germany have developed a similar process. None, however, is highlighted as extensively and involves as many resources as the US primaries.

Most importantly, the following work would not have been possible without the great support of fantastic colleagues, co-authors, friends and family. The second and the third chapters are the result of an inspiring and very instructive co-working process with the excellent scholars Marco Sahm and Steffanie Schmitt, respectively. Without their great guidance, excellent ideas and help, the early ideas would not have filled the pages and resulted in this thesis. Likewise, without the support of my supervisor Florian Herold and the Department of Economics at the University of Bamberg, the work and process of writing and refining my thesis would have been much less enjoyable. I am also very grateful for the support of the Hans-Böckler-Stiftung, which allowed me to focus on my research without having to worry too much about my personal economic situation. In addition, the Hans-Böckler-Stiftung supported me in attending and contributing to insightful seminars and conferences. My subsequent work has benefited greatly from attending various conferences, summer schools and workshops. Moreover, I was delighted to spend three months at the Department of Economics at the University of Exeter, where I gained a deeper insight into the economic community and the work in behavioural economics. Finally, I cannot imagine writing a single sentence of this thesis without the support, love and immense inspiration of my friends and family. Without the discussions, laughter, music and companionship, I would have left the path of science early on.

Chapter 2

Party Politics - A Contest Perspective

Dominik Bruckner, Marco Sahm

Intra-party contests, such as the US primaries, are often used to select a candidate for a subsequent cross-party election. A more accurate selection may improve the quality of the candidate but detract more resources from the subsequent campaign. We model this trade-off as a problem of contest design and show that extreme accuracy levels are optimal: maximum accuracy if the potential candidates are sufficiently heterogeneous, and a highly random selection otherwise. Our result explains varying primary designs on a local as well as global level and sheds light upon the paradox of limited competition within a party.

Keywords: Contest Design, Decisiveness, Collective Action, Elections.
JEL Codes: C72, D72.

2.1 Introduction

Most democratic systems are based upon free competition between political parties. Yet, when we turn to the internal structure of parties, we find a different picture, namely that intra-party competition may be restricted. The internal structure and their constitutional specifications, in particular the competition within parties, vary not only globally but also locally. A simple comparison of political parties across Germany shows that there is a local diversity of party structures. The German constitution only requires that political parties “adhere to democratic principles”. Thus, there is no formal requirement for competition within political parties: The Social Democratic Party of Germany voted by membership decision on their leadership in 2019. In contrast, the leader of the Christian Democratic Union was chosen by an internal party board. A comparison with the United States illustrates the global variation. Similar to Germany the constitution remains silent with respect to the competition within political parties. However, the two major parties in the US, the Republican Party and the Democratic Party, both use a primary to select their leader.

In the following, we analyze the reasons for and effects of the variation in intra-party competition. At first glance, it may seem paradoxical that *democratic* parties may “limit” the extent of democracy within their party structure. However, as we argue this paradox resolves once strategic benefits are taken into account. Thus, this study attempts to provide a rationale for seemingly “autocratic parties”. We develop a model that captures the intra-party perspective, i.e., the primary election, and links it to the inter-party perspective, i.e., the general election. In particular, we analyze the trade-off between the selection quality of candidates and the primary’s intensity. A more accurate selection may improve the quality of the candidate but detract more resources from the subsequent general election campaign because of increased contest intensity. Our results clearly indicate that a party only implements a primary if its members are sufficiently heterogeneous, otherwise it is optimal to decide autocratically. In addition, we show that the optimal primary design does not depend on the incumbent’s strength, but on party resources, the independence of party members, as well as politicians’ career concerns.

We extend our baseline model in a number of ways, including discussing the effect of the number of parties, the number of candidates within a party and information asymmetries. Lastly, we discuss the role of polarization within and between parties. We show that our model and basic mechanism fit well to the problem of a party board serving two audiences: On the one hand, the entire electorate that influences the general election. On the other hand, the party members who influence the outcome of the primary. By varying the design of the primary, a party board takes into account the interdependence of these two audiences.

Several economic studies have extensively examined the competition between political parties. What is surprising is that in this strand of literature political parties are often treated as unitary agents. Moreover, the existing economic literature assumes that parties necessarily hold a primary. In general, there is a paucity of studies that investigate the intra-perspective of a party and relate it to the inter-perspective of competing parties. What remains unclear is exactly how political parties structure their internal competition, and why there is such diversity in party politics. Although there is a growing interest in group competition within the literature on contest theory, this strand of research remains silent on peculiarities of contest applications.

Previous studies mostly considered the political arena as one example among many, without taking into account the underlying differences in contests.

We argue that a party implements an intra-party contest, i.e., a primary, to appoint the most qualified member as leader and/or presidential candidate.[1] As such, a primary is similar to the promotional contest of any other organisation. However, a primary differs from a standard promotional contest in two ways: First, the contestants of the primary are usually already members of the party, i.e., no outsider enters a party's primary. As a result, the party's resources for the general election are at least indirectly influenced by the effort decisions of its members. Second, the link between a primary and a general election entails the key trade-off of choosing between high accuracy, which leads to a highly qualified member becoming party leader, but also implies an exhaustive primary and, consequently, a reduced budget for the general election. While a contest designer of a standard promotional tournament might find maximum decisiveness within the tournament optimal, a decisive primary might actually reduce the chances of winning the general election due to its excessive intensity.

The remainder of this article is structured as follows: We begin by reviewing the related literature as well as specifying our contribution there in. In Section 2.3 we then go on to introduce a simple model of an intra- and inter-party contest. Subsequently, we discuss the peculiarities of the intra-party contest before analyzing the inter-party contest in Section 2.5. Afterwards, we introduce several extensions and discuss the implications of our assumptions. Lastly, we conclude by giving several real world examples our model applies to.

2.2 Related Literature

First and foremost, we contribute to the literature on contest design and theory. Our model design starts from a simple Tullock contest (see Tullock 1980). We focus on the accuracy parameter of the contest success function, also referred to as decisiveness or discriminatory parameter, which is extensively discussed among others in Nti (2004), Alcalde & Dahm (2010), Wang (2010), Yildirim (2015), Ewerhart (2017*b*), Drugov & Ryvkin (2020) and Sahm (2022).[2] In contrast to the existing literature, we explore the decision of the contest designer when she faces a trade-off between accuracy and intensity of the contest. Thus, we analyze an optimal accuracy choice problem, where the contest itself serves as a selection mechanism.

On the empirical side, Winfree (2021) relates to our research as he analyzes the accuracy choices of a sports league designer, when selection quality may be harmful or beneficial to the contest designer. Similar to us, Winfree (2021) focuses on heterogeneity of contestants which partly determines the optimal contest accuracy. Below, we also argue that a contest accuracy can be understood as the contest designer's choice of the contest time-length. Lacomba et al. (2017) experimentally analyze the effect of accuracy on heterogeneous endowed contestants in a conflict. They find that higher contest accuracy leads to a more peaceful outcome. Similarly to our research, Lacomba et al. (2017) emphasize the trade-off of between resources and contest

[1] In some parties there is a formal difference between party leader and presidential candidate. Nevertheless, usually a party leader also becomes presidential candidate. Thus, in the following we assume that a party leader is also the party's presidential candidate.

[2] An extensive literature overview is given by Mealem & Nitzan (2016).

intensity influenced by accuracy concerns. They argue that accuracy is an important tool to circumvent costly conflict.

Second, we add to the rapidly growing literature on group contests (see e.g. Choi et al. 2016). The central trade-off we analyze occurs because the intra-group contest affects the outcome of the inter-group contest. A key aspect of our model is the heterogeneity of group members qualification. Dependent on the intra-team contest a less or more qualified candidate will be promoted as candidate for the inter-team contest. The heterogeneity in the contestant group, however, also determines the intra-contest intensity (see e.g. Berger & Nieken 2016). To the best of our knowledge we are the first ones to analyze the accuracy parameter in a group contest setting.

Third, we contribute to the literature on political processes, in particular the internal perspective of political parties. The economic literature is scarce in this regard. To name a few exceptions that are most relevant to our research: Bhattacharya & Rampal (2019) analyze a group contest with varying group size and strength, but refrain from motivating the intra-group contest. Crutzen et al. (2020) analyze the effects of varying prize structures in intra-group contests and relate their findings to open and closed list representation within parties. The model of Crutzen et al. (2020) captures different designs of intra-party competition, but does not include any heterogeneity of contestants which is one of the central reasons for designing a contest. Sheremeta (2010) conducts an experiment where he tests a theoretical model of party competition. In particular, he studies the effect of carry-over from primaries to general election as well as the number of candidates. In our model, we assume that a party has a limited budget for both the primary and the general election. In a sense, a party board aims to carry over as many resources as possible from the primary to the general election. Lastly, Mattozzi & Merlo (2015) analyze reasons for politicians' mediocracy. Among other things, they highlight the role of the discouragement effect and its interaction with the competition effect. Mattozzi & Merlo (2015) argue that parties may select a group of mediocre party leaders in order to extract the most aggregated group effort in the general election. In contrast to our research, they mainly focus on the competitive design of the general election.

The common ground of these economic studies is that parties necessarily use a primary, i.e., intra-party contest, to select their candidates. In contrast, our research focuses on the endogenous decision concerning a primary's design. We analyze the optimal choice if intra- and inter-group contests are linked.

Within the political science research, Serra (2011) proposes a theoretical framework and argues that parties implement primaries to reveal candidates' abilities. In addition, Serra (2011) relates the internal structure of parties to the ideology of members. If parties implement a primary, candidates may be more prone to ideological extremism of other party members. Other aspects regarding internal party structures are party unity and members' participation (see for example Scarrow 2021, Tromborg 2021, Kernell 2015). One argument of Kemahlioglu et al. (2009) is that parties hold primaries to coordinate themselves. Kemahlioglu et al. (2009) also present empirical evidence of Latin American democracies suggesting that the party size, the party's ideology, and the incumbency status affect the choice of holding a primary. Schindler (2021) highlights empirical evidence that party boards differ in comparison to broad membership selection of a leader. In particular, Schindler (2021) proposes that party boards select the leader in a more "professional" way, taking into account a wider range of aspects, such as party unity, and deciding in a more coordinated way. In our study we discuss and build on the empirical findings of the political science research. We interpret our model in terms of party unity and highlight the incentives of a party board varying the primary design.

2.3 Model

We consider the political competition between two parties $P \in \{A, B\}$ as a sequential game with three stages. At the first stage, the board of each party designs a primary election. In these intra-party contests, which take place at the second stage, two applicants with heterogeneous qualifications compete against each other to become the party's candidate for the subsequent general election. At the third stage, the general election takes place as an inter-party contest between the two selected candidates.[3]

Before we specify the three stages of the game more formally and in reverse order, let us briefly describe the basic trade-off that the model represents. A candidate's success in the general election depends on both, her qualification (ability, motivation) and her available resources. Each party board maximizes the winning probability of its candidate in the general election by designing its primary election. A design that improves the selection quality may, however, also intensify intra-party competition during the primary, leaving fewer resources for the inter-party competition during the general election.

2.3.1 Third Stage: The General Election

At the third stage, the general election takes place. It is modeled as an inter-party lottery contest between the two selected candidates. The candidate of party $P \in \{A, B\}$ with qualification $v^P = 1/c^P$ chooses the investment y^P in order to maximize the probability of winning the election

$$\pi^P = \frac{y^P}{y^P + y^Q}, \tag{2.1}$$

subject to the constraint that the investment costs $c^P y^P$ must not exceed the party's remaining budget B^P. We assume that the remaining budget equals the party's initial resources R^P less the applicants' aggregate investments I^P during the intra-party contest, i.e., during the primary election at the second stage: $B^P = R^P - I^P$.

2.3.2 Second Stage: The Primary Election

At the second stage, a primary election takes place in each party. It is modeled as an intra-party Tullock contest between two members of that party. The two competing applicants $i \in \{1, 2\}$ in party $P \in \{A, B\}$ may differ in their qualification (ability, motivation) $v_i^P = 1/c_i^P$, expressed

[3]For simplicity, we restrict the analysis of the baseline model to two parties and two applicants each. We discuss extensions to more parties or applicants in Section 2.6.1.

by the inverse of their constant marginal investment cost $c_i^P \in [1, \infty)$. The winning probability of applicant $i \in \{1, 2\}$ in party $P \in \{A, B\}$ is given by the contest success function (CSF)

$$p_i^P = \begin{cases} \frac{(x_i^P)^{r^P}}{\sum_{j=1}^2 (x_j^P)^{r^P}}, & \text{if } X^P := \sum_{j=1}^2 x_j^P > 0, \\ 1/2, & \text{if } X^P = \sum_{j=1}^2 x_j^P = 0, \end{cases} \tag{2.2}$$

where x_i^P denotes the effort of applicant i, X^P denotes aggregate effort and the parameter r^P denotes the accuracy level of the contest in party P.[4]

We may interpret the applicants' efforts in a physical sense as money or time they invest during the primaries. These resources are then no longer available for investments into the general election.[5] In a metaphorical sense, the applicants' aggregate effort can be understood as a measure of intra-party dissent which the electorate dislikes and which therefore reduces the party's probability of winning the general election.

We assume that each applicant $i \in \{1, 2\}$ chooses her effort x_i^P in order to maximize her expected payoff from candidateship in party P

$$Eu_i^P = p_i^P - c_i^P x_i^P \quad \text{or, equivalently,} \quad EU_i^P = p_i^P v_i^P - x_i^P. \tag{2.3}$$

This assumption implies a kind of myopic behavior by the applicants as they only value their own success in the primary election but not their party's success probability in the subsequent general election. As we argue below in Section 2.6, assuming more sophisticated, far-sighted objectives does not fundamentally change the basic trade-off.

2.3.3 First Stage: The Design of the Primaries

While in most democracies, such as Germany or the United States, the design of the general election is usually determined by the constitution, parties are free to choose how to select their candidates. We assume that (the board of) each party designs the primary election in order to maximize the probability of winning the general election. Notice that party applicants' investment during the primaries impact both determinants of success in the general election: the party's' remaining budget and the expected qualification of the party's designated candidate. The two objectives for designing the primary – selecting the better qualified applicant as the party's candidate and saving as many resources as possible – may, however, be conflicting.

We capture the potential trade-off between selection quality and resource management by considering the technology of the intra-party contest. In particular, we analyze the accuracy level r^P as the relevant parameter for party P's design of the primary election. Low values of r^P imply a noisy, probabilistic CSF and thus result in a highly random selection. Higher values of r^P reduce the noise and improve the selection quality but may come at the cost of higher investment. With regard to the political arena, we interpret the accuracy level as a measure of

[4]In the related literature, the accuracy level is also referred to as the discriminatory power or decisiveness parameter.

[5]Even though (the investments during) the primaries may have positive external effects on a party's success in the subsequent general election by generating publicity/momentum for its candidate and increasing voter turnout, it would be (at least weakly) more efficient to spend these resources directly on the general election campaign (by emphasizing the differences between rather than within parties).

the length (time duration) of the primary election campaign or the number of events: the longer a primary lasts and the more events it involves, the more decisive it becomes but, at the same time, the more resources it may absorb.[6]

2.3.4 Information Structure and Timeline

How important the selection quality of a primary election actually is, depends crucially on the extent to which applicants differ in their qualifications. We assume the following information structure: At the beginning of an election period, each applicant $i \in \{1, 2\}$ in party $P \in \{A, B\}$ independently draws her qualification v_i^p. Within each party, the party board and the applicants observe the qualifications of both applicants, but the primary election is the only way to verify these qualifications towards the supporters and legitimate the selected candidate. We normalize $v_1^p = 1$ and denote $v_2^p = w^P \in (0, 1)$. Thus, without loss of generality, applicant 1 has an equal or higher qualification compared to applicant 2.

Figure 3.1 summarizes the events of our model and illustrates the order in which they take place.

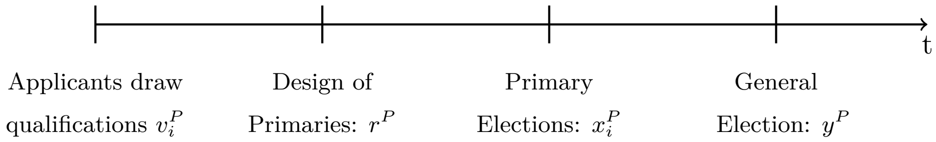

Figure 2.1: Timeline.

2.4 Analysis

In this section, we analyse the sequential game by backward induction and characterize the basic properties of the subgame perfect equilibrium (SPE).

2.4.1 Third Stage: General Election

Once the winners of the primary elections are nominated as the parties' candidates, they compete against each other in the general election with their qualifications v^P and remaining budget $B^P = R^P - I^P$. Candidates choose y^P in order to maximize the success probability π^P as given by equation (2.1) subject to $y^P c^P \leq B^P$ or, equivalently, $y^P \leq v^P B^P$. Because there is no other use for a party's resources, the budget constraint is binding in equilibrium and the success probability of party $P \in \{A, B\}$ equals

$$\pi^P = \frac{v^P(R^P - I^P)}{v^P(R^P - I^P) + v^Q(R^Q - I^Q)}. \tag{2.4}$$

[6] One may argue, for example, that parties in the US design a highly accurate primary, in which the quality of each applicant is thoroughly scrutinized: US primaries are usually held over a longer period of time, e.g., the Democratic primary in 2020 started on the 3^{rd} of February and ended on the 11^{th} of August. During this time period there were several events such as public broadcasts where applicants competed for voters. Thus, the public accessibility and transparency contributed to our notion of a highly accurate primary design.

2.4.2 Second Stage: Primary Election

During the primary election of party $P \in \{A, B\}$, each applicant $i \in \{1, 2\}$ chooses the effort x_i that maximizes her expected payoff from candidateship as given by Equation (2.3).[7] Depending on the level of accuracy r, three different Nash equilibria may arise (see, e.g. Ewerhart 2017*b*, Table 1).

First, if $0 \leq r \leq 1 + w^r$ the equilibrium is unique and in pure strategies. It entails the effort levels

$$x_1 = \frac{rw^r}{(1+w^r)^2} \quad \text{and} \quad x_2 = \frac{rw^{r+1}}{(1+w^r)^2},$$

winning probabilities

$$p_1 = \frac{1}{1+w^r} \quad \text{and} \quad p_2 = \frac{w^r}{1+w^r},$$

aggregate effort

$$X = x_1 + x_2 = \frac{rw^r(1+w)}{(1+w^r)^2}, \tag{2.5}$$

and aggregate investment

$$I = c_1 x_1 + c_2 x_2 = \frac{x_1}{v_1} + \frac{x_2}{v_2} = \frac{2rw^r}{(1+w^r)^2} = \frac{2}{1+w} X. \tag{2.6}$$

Second, if $w^r + 1 < r \leq 2$ the equilibrium is unique and in semi-mixed strategies. It entails the (expected) effort levels

$$x_1 = \frac{w}{r}(r-1)^{\frac{r-1}{r}} \quad \text{and} \quad E(x_2) = \frac{w^2}{r}(r-1)^{\frac{r-1}{r}},$$

winning probabilities

$$p_1 = 1 - \frac{w}{r}(r-1)^{\frac{r-1}{r}} \quad \text{and} \quad p_2 = \frac{w}{r}(r-1)^{\frac{r-1}{r}},$$

expected aggregate effort

$$E(X) = \frac{w(1+w)}{r}(r-1)^{\frac{r-1}{r}}, \tag{2.7}$$

and expected aggregate investment

$$E(I) = \frac{2w}{r}(r-1)^{\frac{r-1}{r}} = \frac{2}{1+w} E(X). \tag{2.8}$$

Notice that in this range, the winning probability of the stronger applicant, p_1, is an increasing function of r and the expected aggregate effort, $E(X)$, is a decreasing function of r.

Finally, for $r > 2$ all equilibria are in mixed-strategies and equivalent to the unique equilibrium of the all-pay auction (APA) with respect to expected efforts, winning probabilities, and

[7] The analysis is the same for both parties. Therefore, here and below, we omit the superscript P wherever confusion can be excluded.

payoffs. We call this an APA-equilibrium. It entails the expected effort levels

$$E(x_1) = \frac{w}{2} \quad \text{and} \quad E(x_2) = \frac{w^2}{2},$$

winning probabilities

$$p_1 = 1 - \frac{w}{2} \quad \text{and} \quad p_2 = \frac{w}{2},$$

expected aggregate effort

$$E(X) = \frac{w(1+w)}{2}, \tag{2.9}$$

and expected aggregate investment

$$E(I) = w = \frac{2}{1+w} E(X). \tag{2.10}$$

2.4.3 First Stage: Accuracy Choice

Anticipating the applicants' behavior during the primaries and the candidates' behavior during the general election, the board of each party P chooses the accuracy level for its primary election r^P in order to maximize the own candidate's expected success probability in the general election. Using equation (2.4), the expected success probability of party A's candidate in the general election is given by

$$\begin{aligned} E(\pi^A) = {} & p_1^A p_1^B E\left[\frac{(R^A - I^A)}{(R^A - I^A) + (R^B - I^B)} \mid x_1^A \geq x_2^A, x_1^B \geq x_2^B\right] \\ & + p_1^A p_2^B E\left[\frac{(R^A - I^A)}{(R^A - I^A) + w^B(R^B - I^B)} \mid x_1^A \geq x_2^A, x_1^B < x_2^B\right] \\ & + (1 - p_1^A) p_1^B E\left[\frac{w^A(R^A - I^A)}{w^A(R^A - I^A) + (R^B - I^B)} \mid x_1^A < x_2^A, x_1^B \geq x_2^B\right] \\ & + (1 - p_1^A) p_2^B E\left[\frac{w^A(R^A - I^A)}{w^A(R^A - I^A) + w^B(R^B - I^B)} \mid x_1^A < x_2^A, x_1^B < x_2^B\right], \end{aligned} \tag{2.11}$$

where $I^P = \frac{2}{1+w^P} X^P$ for $P \in \{A, B\}$ and (conditional) expectations are based on the distributions specifying the (potentially) mixed-strategies in the equilibria of the primaries.

The objective function (2.11) reflects a complex strategic decision problem. In general, party A's optimal choice of the accuracy level r^A may not only depend on the exogenous parameters of the model but also on party B's choice of the accuracy level r^B. We can show, however, that party A's best response to any choice of r^B will be polarized: party A always chooses an accuracy level either above the upper threshold $r^A \geq 2$ or below a lower threshold $r_H < 2$, and so this holds in equilibrium as well.

To see this, notice that X^A and p_1^A do not explicitly depend on r^B. Moreover, $\partial E(\pi^A)/\partial X^A < 0$ and $\partial E(\pi^A)/\partial p_1^A > 0$ for all r^B, as straightforward calculations show. For any given r^B, the maximization of $E(\pi^A)$ by the choice of r^A thus entails two (possibly conflicting) objectives: the minimization of aggregate primary effort X^A and the maximization of the strong applicant's selection probability p_1^A. Ewerhart (2017*b*, Table 1) observes that for any given w^A both, p_1^A and

X^A are continuous functions of r^A. While $\partial p_1^A/\partial r^A > 0$ for all $0 \leq r^A < 2$ and $\partial p_1^A/\partial r^A = 0$ for all $r^A \geq 2$ (Ewerhart 2017*b*, Table 1), aggregate effort X^A is an inverted U-shaped function of r^A with a unique maximum in the region of pure-strategy equilibria where $r^A \leq 1 + (w^A)^{r^A}$ (Sahm 2022, Proposition 2).

The objective function (2.11) thus entails a trade-off between the selection quality and the minimum aggregate effort. The work by Sahm (2022) then implies that party A optimally solves this trade-off by choosing either an all-pay auction, i.e., $r^A \geq 2$, or an accuracy level $r^A < r_H$ that equates aggregate effort in the pure-strategy equilibrium according to equation (2.5) and expected aggregate effort of the all-pay auction equilibrium according to equation (2.9):

$$\frac{r(w^A)^r(1+w^A)}{(1+(w^A)^r)^2} = \frac{(1+w^A)w^A}{2} \quad \Leftrightarrow \quad H(w^A, r) := (1+(w^A)^r)^2 - 2r(w^A)^{r-1} = 0$$

Symmetric arguments also apply to party B. This yields

Proposition 1 *Each party $P \in \{A, B\}$ chooses a polarized design for its primary election: in equilibrium, the accuracy level r^P satisfies either $r^P < r_H(w^P)$ or $r^P \geq 2$.*

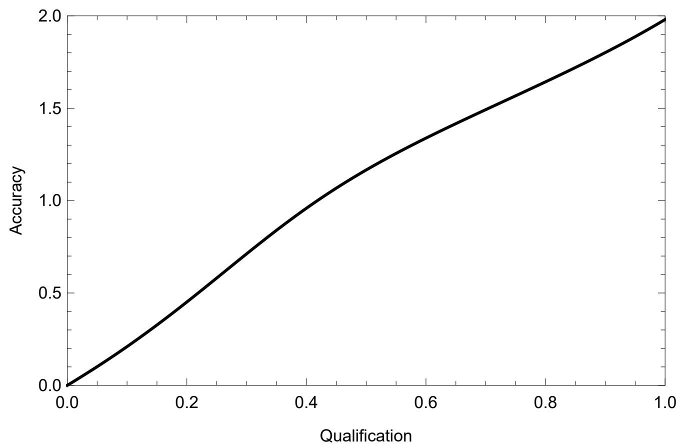

Figure 2.2: Lower threshold r_H as a function of the qualification ratio w^P.

Figure (2.2) illustrates how the lower threshold r_H depends on the ratio of the applicants' qualifications w^P within the respective party: the graph represents all combinations satisfying $H(w^P, r_H) = 0$. Notice that if it is optimal to choose a low accuracy, r_H is only an approximate upper bound for this choice because it yields the same aggregate effort as the all-pay auction but a reduced selection quality. To compensate for the reduced selection quality, the optimal accuracy must reduce aggregate effort (not only marginally but) significantly and thus has to be (not only marginally but) significantly smaller than r_H. For instance, if the two candidates of party P have the same qualification ($w^P = 1$), obviously, a purely random primary is optimal, i.e., $r^P = 0 \ll 2 = r_H(1)$. The examples of the following section illustrate that such a complete polarization is rather the rule than the exception.

2.5 Competing against an Incumbent

To further illustrate the basic trade-off between maximum selection quality and minimum aggregate effort in the primary election and to determine the optimal choice of the respective accuracy level, we now restrict the analysis to party A competing against an incumbent from party B. As before, party A uses a primary election to select one of two applicants $i \in \{1, 2\}$ as its candidate in the subsequent general election. In contrast, party $B = IN$ forgoes the primary election and directly nominates the incumbent as its candidate for the general election.[8] This setting applies, for example, to the US election system where the incumbent president is usually also the party's nominee for the upcoming general election.

We assume that both, the incumbent's qualification v^{IN} and resources R^{IN} are common knowledge. Accordingly, party A's objective function (2.11) reduces to:

$$\begin{aligned} E(\pi^A) = p_1^A E &\left[\frac{(R^A - I^A)}{(R^A - I^A) + v^{IN} R^{IN}} \mid x_1^A \geq x_2^A \right] \\ &+ (1 - p_1^A) E \left[\frac{w^A (R^A - I^A)}{w^A (R^A - I^A) + v^{IN} R^{IN}} \mid x_1^A < x_2^A \right]. \end{aligned} \tag{2.12}$$

In the first subsection, we fix $v^{IN} R^{IN} = 1.5$ and numerically determine party A's optimal choice of the accuracy level as a function of the qualification ratio w^A of its applicants. In the second subsection, we examine how this optimal accuracy choice responds to variations in the incumbent's qualification and budget on the one hand, and party A's own budget on the other.

2.5.1 Numerical Solution

According to Proposition 1, the optimal accuracy level r^A satisfies either $r^A < r_H(w^A)$ or $r^A \geq 2$. We first determine the optimal *low* accuracy level, i.e., the accuracy level r^A that maximizes equation (2.12) subject to $r^A < r_H(w^A)$. We then compare the resulting expected success probability $E(\pi^A)$ with the expected success probability that results from choosing a *high* accuracy level $r^A \geq 2$.

Optimal low accuracy level

Figure 2.3 illustrates the optimal low accuracy level r^A as a function of the qualification ratio w^A. If this ratio exceeds a threshold level $\tilde{w} \approx 0.32$, the optimal low accuracy is $r^A = 0$. Put differently, if the applicants' qualifications are sufficiently close, a purely random selection of the candidate is optimal as it preserves all the party's resources for the subsequent general election. For more heterogeneous qualifications $w^A < \tilde{w}$, however, the optimal low accuracy is positive, $0 < r^A < r_H(w^A)$. Investing some resources increases the likelihood that the strongest candidate will be chosen, and therefore pays off in the general election.

[8] An alternative interpretation would be that the incumbent party only designs a primary election "pro forma", to officially nominate the only applicant as their candidate.

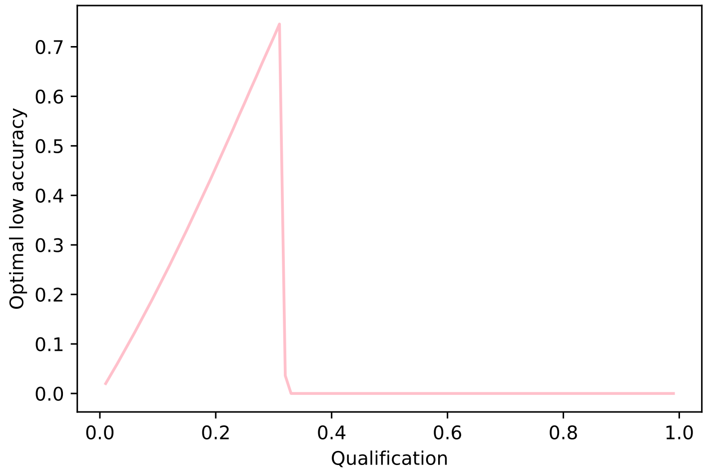

Figure 2.3: Optimal low accuracy.

Comparison of optimal low and high accuracy level

The pink line in Figure 2.4 depicts the expected success probability $E(\pi^A)$ resulting from the optimal low accuracy level $r^A < r_H(w^A)$ as a function of the qualification ratio w^A of party A's applicants. The success probability is increasing in w^A because the disadvantage of selecting the weaker applicant will decrease if the difference in the applicants' qualification decreases.

Instead, if party A chooses a high accuracy level $r \geq 2$, this implies an APA equilibrium in its primary election. The resulting success probability in the general election is illustrated by the black line in Figure 2.4. Obviously, the success probability in an APA equilibrium is a decreasing function of the qualification ratio w^A because the primary election absorbs the more resources the closer the contest between party A's applicants gets.

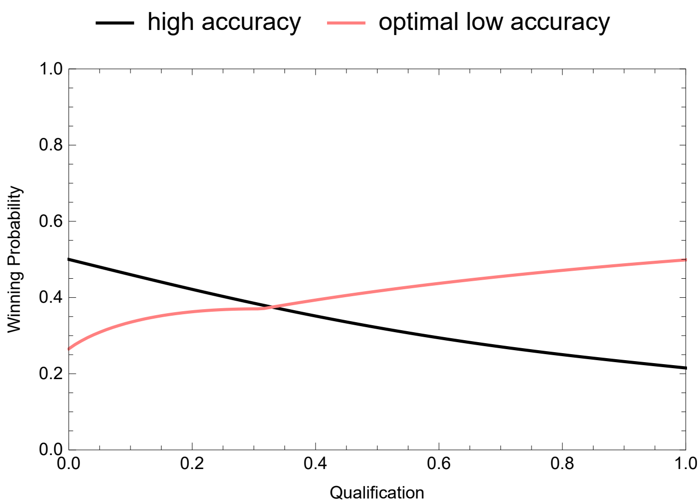

Figure 2.4: Maximum winning probability, with $R_A = R_B = 1.5$.

As Figure 2.4 illustrates, the current specification of the model leads to a unique intersection of the pink and the black line at a certain qualification ratio $\hat{w} \approx 0.34$. To the right of this threshold, i.e., for $w^A \geq \hat{w}$, party A maximizes its expected success probability in the general election by implementing a primary election with the optimal low accuracy level. Notice, however, that the optimal low accuracy level is $r^A = 0$ in this range since $\hat{w} > \tilde{w}$. By contrast, to the left of the intersection, i.e., for $w^A < \hat{w}$, party A optimally chooses a high accuracy level $r^A \geq 2$ that implies an APA equilibrium in the primary election. We summarize our observations in

Numerical Result 1 *Competing against an incumbent IN with $v^{IN}R^{IN} = 1.5$, party A uses a completely polarized primary election: it is optimal to choose*

1. *maximum accuracy $r^A \geq 2$ if $w^A < \hat{w}$,*
2. *minimum accuracy $r = 0$ if $w^A \geq \hat{w}$.*

These findings are intuitive: For high qualification ratios, saving resources is more important than an accurate selection because the applicants' qualifications are close anyway. Instead, for low qualification ratios, the increased chances of a highly qualified candidate due to a more accurate selection offsets the decrease of available resources resulting from an intense primary election.

2.5.2 Comparative Statics

In this section we illustrate how variations of different parameter values effect our results.

Incumbency

We first consider a variation in the strength of the incumbent from party B. Figure 2.5 illustrates the comparison between party A's equilibrium winning probabilities facing a weak incumbent, with $v^{IN}R^{IN} = 1.5$, and a strong incumbent, with $v^{IN}R^{IN} = 4$, respectively. Obviously, the expected winning probability, $E(\pi^A)$, increases the weaker the incumbent. However, there is no difference with respect to the optimal primary design of party A. Numerical Result 1 still applies. Regardless of the incumbent's strength, party A faces an equally high threshold level $\hat{w}$ above which it is optimal to refrain from choosing a maximum accuracy. Intuitively, party A seeks to maximize its expected impact in the general election regardless of the opponent's strength.

Party resources and independent candidates

By contrast, a change in a party's resources or the independence of its candidates leads to a different optimal primary design, i.e., a change in the threshold level $\hat{w}$.

For example, consider a situation where the initial resources of party A are scarcer. This shifts the emphasis in the trade-off party A faces from high selection quality to low contest intensity: the scarcer the party's budget, the more important a low primary intensity becomes. Figure 2.6 illustrates the effect of a change in resources regarding the primary design, from high budget, $R^A = 4$, to low budget, $R^A = 1.5$. First, it is straightforward to see that the expected probability of winning, $E(\pi^A)$, decreases with a depletion of resources. Second, the threshold $\hat{w}$ decreases with the reduction in budget, i.e., $\hat{w}_{R^A=1.5} < \hat{w}_{R^A=4}$. If a party's budget is sufficiently high, a party can afford a high primary intensity to increase selection quality. Vice versa, if the

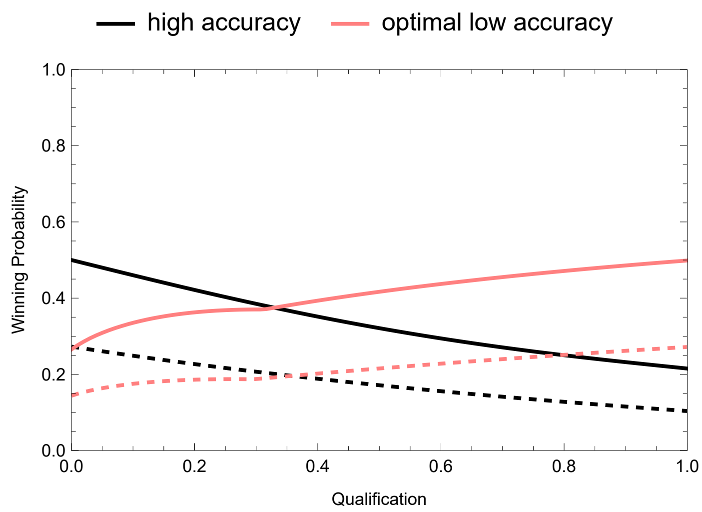

Figure 2.5: Weak ($v^{IN}R^{IN} = 1.5$, solid) versus strong ($v^{IN}R^{IN} = 4$, dashed) incumbent.

budget is low, a party only implements a decisive primary for very steep qualification differences. Therefore, an increase in the budget leads to an increase in $\hat{w}$.

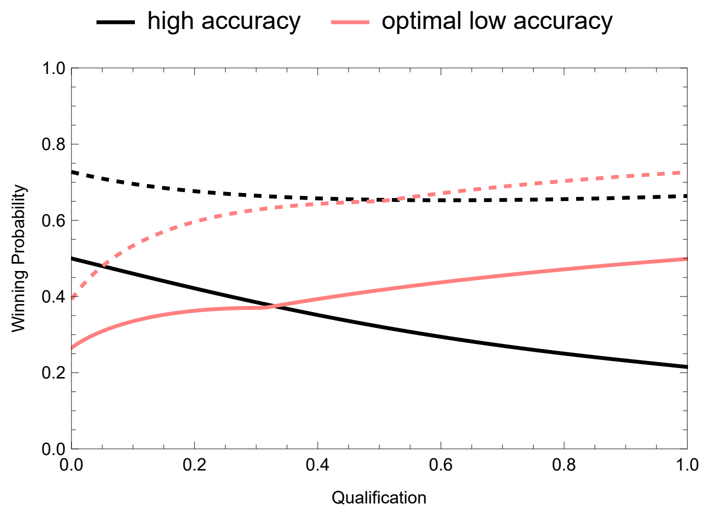

Figure 2.6: Low budget ($R^A = 1.5$, solid) versus high budget ($R^A = 4$, dashed).

A similar argument, with the opposite effect, can be made for primaries where candidates act independently of party resources.[9] Members' independence of party resources can be captured by $\delta \in [0, 1]$:

$$B^A = R^A - \delta(c_1x_1 + c_2x_2).$$

If party members pay by means of their own resources this would mean $\delta \to 0$. The effect of changes in δ is congruent to changes in R^A. Therefore, as party independence increases, i.e., $\delta \to 0$, the threshold $\hat{w}$ increases, because the budget is less constrained. In the extreme case of complete independence, $\delta = 0$, it is always optimal for a party to implement a primary

[9]We assume that members are treated equally with respect to independence of resources and are symmetric with respect to own resources.

with maximum accuracy, because the trade-off between selection quality and contest intensity is eliminated.[10]

2.6 Extensions

We now consider various extensions of our model. We argue that the basic results and mechanism still hold for other model specifications such as a larger number of parties or candidates and different information structures. Moreover, we extend the model to more farsighted applicants who take into account the continuation value of potentially winning the general election after a successful primary. Based on this extension, we illustrate that a reinterpretation of the applicants' cost parameters can explain differences in a primary's accuracy as a consequence of polarization within parties.

2.6.1 Multiple Parties and Applicants

We first consider the case of multiple parties and then discuss the case of multiple applicants per party.

Multiple parties

Our baseline model assumes only two parties, which is a valid description of the situation in countries such as the U.S. in which, in effect, a two-party system prevails. In many other democracies, however, more than two parties compete in the general election.[11] With $n \in N$ different parties, the probability of party P's candidate winning the general election becomes

$$\pi^P = \frac{y^P}{y^P + \sum_{j \neq p}^{n} y^j}. \tag{2.13}$$

Thus, a larger number of parties will, ceteris paribus, increase competition and decrease party P's winning probability. Similar to the comparative statics of Section 2.5.2, however, the (trade-off determining the) optimal level of a primary's accuracy remains unaffected by the number of competing parties. The intuition is, as above, that a party seeks to maximize its expected impact in the general election regardless of the strength or number of competitors.

Multiple applicants

By nature, intra-party competition often features the dispute between two leading members. And even if there are more applicants to begin with, in practice, primaries usually boil down

[10] This result may explain the global difference in party politics: Because party members in the US system mainly pay by themselves when they participate in the primaries, i.e., the candidates' primary budget is independent from the party's budget, parties can afford to hold primaries. In the German system, primaries are mainly paid out of the party budget, so the trade-off is more severe.

[11] For example, after the general election in 2021, members of eight different parties entered the German parliament (Bundestag) and thus had the right to vote in the election of the Federal Chancellor. Three of the parties nominated an own candidate with a reasonable chance for chancellorship.

to a contest between the two most promising aspirants later on.[12] These situations are well-captured by our model assuming only two applicants per party.

The formal treatment of more than two (heterogeneous) applicants per party faces some technical problems. For $N \in$ potential applicants within a party with given qualifications $v_1 \geq v_2 \geq \ldots \geq v_N$, a unique pure-strategy Nash equilibrium of the respective primary exists only if $r \leq 1$ (see Stein 2002, Cornes & Hartley 2005, Matros 2006). If $r > 1$, but still sufficiently low, several pure-strategy Nash equilibria exist (see Ryvkin 2007), even if players are symmetric (see Perez-Castrillo & Verdier 1992). For $r \geq 2$, an APA-equilibrium always exists (see Alcalde & Dahm 2010), and any (mixed-strategy) Nash equilibrium is an APA-equilibrium if r is sufficiently large (see Ewerhart 2017*a*). For any given $N \in$ and $r \geq 2$, however, there are qualifications $v_1 \geq v_2 \geq \ldots \geq v_N$ such that a non-APA-equilibrium exists as well (see Ewerhart 2017*a*). Thus, we are not only confronted with the issue of multiple equilibria. An additional problem is that in the range where multiple equilibria exist, the set of Nash equilibria has not yet been fully characterized in the literature.

One way to circumvent these problems is to restrict the search for an optimal accuracy r to the range of unique equilibria, i.e., $r \leq 1$, or r sufficiently large to enforce an APA-equilibrium. The above analysis of the case with two applicants suggests that this is the relevant range, anyway.

On the one hand, if r is chosen sufficiently large to enforce an APA-equilibrium, only the two strongest applicants are active and the equilibrium values are the same as in the above analysis with only two applicants (see Hillman & Riley 1989). On the other hand, for $r = 1$ Matros (2006) shows that the $K \leq N$ strongest applicants are active in the unique pure-strategy Nash equilibrium, and the number of applicants N (weakly) increases aggregate effort but decreases individual winning probabilities.

A higher number of applicants thus aggravates the trade-off between selection quality and resource dissipation and leads to an even more polarized accuracy choice in the following sense: Whenever an accuracy r that enforces an APA-equilibrium is preferred over any $r \leq 1$ with two applicants, it is, a fortiori, also preferred with more than two applicants. By contrast, if the optimal accuracy with two applicants is some $r^* \leq 1$, then, with more than two applicants, the party board will either find an accuracy r that enforces an APA-equilibrium more preferable or optimally choose some $r^{**} \leq r^*$.

2.6.2 Alternative Information Structure

The timing of events considered so far (see Figure 3.1) reflects the implicit assumption that the party board is able to adjust the accuracy in response to realized differences in the applicants' qualification from primary to primary on short notice. However, in some cases, such as the U.S., long-standing habits shape the design of the primaries and changes may only materialize in the long run. The alternative timeline in Figure 2.7 then better captures the true sequence of events: now the party board chooses the accuracy for its primary before the applicants draw

[12] Intra-party elections are often organized in stages. For example, in the U.S. both, the democratic and republican party organize their primaries in the different federal states in a (partially) sequential order. Candidates who are unsuccessful in states with early primaries usually stop their campaign and drop out of the races in later states.

their qualifications. Obviously, the decision on the accuracy of the primary must then be based on the expected rather than the realized differences in the applicants' qualifications. This makes the formal analysis more involved but does not alter the basic trade-off between selection quality and resource dissipation.

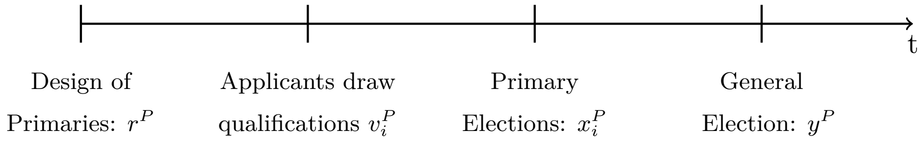

Figure 2.7: Alternative Timeline.

2.6.3 Career Concerns and Political Polarization

In this subsection, we consider applicants with career concerns and reinterpret their heterogeneity as a measure of political polarization within their party. To facilitate the analysis, we stick to the case of party A competing against an incumbent with an exogenous impact y^{IN} in the general election. Below, we omit the superscript for the variables of party A.

Career concerns

So far, we have assumed that applicants are myopic in the sense that they only value becoming the party's candidate but do not derive any additional utility from the associated possibility of winning the subsequent general election. In contrast, we now assume that applicants have career concerns and (only) value the chance that winning the primary will give them the opportunity to win the subsequent general election. Equation (2.3), which describes applicant 1's expected utility from investing effort x_1 in the primary, thus has to be modified as follows:

$$Eu_1 = p_1\pi_1 - c_1x_1 \quad \text{or, equivalently,} \quad EU_1 = p_1v_1\pi_1 - x_1, \tag{2.14}$$

where

$$\pi_1 = \frac{R - c_1x_1 - c_2x_2}{R - c_1x_1 - c_2x_2 + c_1y^{IN}}$$

denotes applicant 1's probability of winning the general election according to equation (2.4). Analogously,

$$EU_2 = p_2v_2\pi_2 - x_2 \quad \text{and} \quad \pi_2 = \frac{R - c_1x_1 - c_2x_2}{R - c_1x_1 - c_2x_2 + c_2y^{IN}}.$$

The modified game is strategically more complex because the effective valuations of winning the primary, $v_i\pi_i$, now also depend on the investments x_1 and x_2.[13] However, $c_1 < c_2$ implies $\pi_1 > \pi_2$ and thus $v_1\pi_1 > v_2\pi_2$ for all x_1 and x_2. Put differently, as in the baseline model above,

[13] Notice that this dependency yields additional incentives to reduce investments for both applicants as

$$\frac{\partial \pi_i}{\partial x_i} = -\frac{c_iy^{IN}}{(R - c_1x_1 - c_2x_2 + c_iy^{IN})^2}.$$

Since straightforward calculations show that $|\frac{\partial \pi_1}{\partial x_1}| < |\frac{\partial \pi_2}{\partial x_2}|$ for all x_1 and x_2, the marginal disincentives are always stronger for the weaker applicant.

the effective valuation of the more qualified applicant is always larger than that of the less qualified applicant. In this sense, the structure of the strategic decision problems faced by the applicants in the primary remains the same. Accordingly, when choosing the accuracy r of the primary, the party board still faces an analog trade-off between selection quality and resource dissipation.

Political polarization

Up to now, we have interpreted the applicants' heterogeneous costs as a form of vertical differentiation with respect to their qualifications. Assuming that applicants have career concerns and that their effort costs may differ between the primary and the general election, also allows for interpreting their heterogeneity as a form of horizontal differentiation that describes their political polarization.[14]

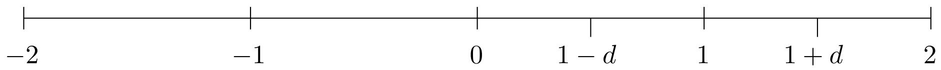

Figure 2.8: Reinterpreting the applicants' heterogeneity as political polarization.

On a Hotelling-line from -2 to 2, voters (in the general election) are centered around 0, but members (i.e., voters in the primary) of party A (B) are centered around 1 (-1). Parameter $d \in [0,1]$ expresses the applicants' heterogeneity as a measure of political polarization: $1-d$ describes the position of applicant 1, whereas $1+d$ describes the position of applicant 2. Assume that the applicants' investment costs differ between the primary and the general election and are equal to 1 plus the distance to the decisive (median) voter of the respective election. Hence, the two applicants' investment costs in the primary are identical and equal to $k_i = 1+d$. Their investment costs in the general election, however, differ – the more so the larger their political polarization d: applicant 1 has lower costs than applicant 2, $c_1 = 2-d < 2+d = c_2$.

Similar to the previous subsection, applicant 1's expected utility from investing effort x_1 in the primary is then given by

$$Eu_1 = p_1\pi_1 - (1+d)x_1 \quad \text{or, equivalently,} \quad EU_1 = p_1 v\pi_1 - x_1,$$

where $v = \frac{1}{1+d}$ and

$$\pi_1 = \frac{R-(1+d)(x_1+x_2)}{R-(1+d)(x_1+x_2)+(2-d)y^{IN}}.$$

Analogously,

$$EU_2 = p_2 v\pi_2 - x_2 \quad \text{and} \quad \pi_2 = \frac{R-(1+d)(x_1+x_2)}{R-(1+d)(x_1+x_2)+(2+d)y^{IN}}.$$

As above, $c_1 < c_2$ implies $\pi_1 > \pi_2$ and thus $v\pi_1 > v\pi_2$ for all x_1 and x_2. Again, the effective valuation of the more qualified applicant is always larger than that of the less qualified applicant

[14] Alternatively, the political polarization discussed below can be described as party unity or the difference of party members' ideology.

and, in this sense, the structure of their strategic decision problems remains the same. Accordingly, when choosing the accuracy r of the primary, the party board faces an analog trade-off between selection quality and resource dissipation.

2.7 Conclusion

We have studied intra-party contests, such as the US primaries, which are often used to select a candidate for a subsequent cross-party election. A more accurate selection may improve the quality of the candidate but detract more resources from the subsequent campaign. We have modeled this trade-off as a problem of contest design and shown that extreme accuracy levels are optimal: maximum accuracy if the potential candidates are (expected to be) sufficiently heterogeneous, and a highly random selection otherwise.

Various extensions of the model suggest that, qualitatively, these findings do not depend on the exact number of political parties, applicants per party, the information structure, or whether applicants are myopic or far sighted. The heterogeneity among applicants may not only be interpreted as different qualifications in a vertical sense but also as political polarization in a horizontal sense. Our results explain varying primary designs on a local as well as on a global level and shed light upon the paradox of limited competition within a party.

Chapter 3

Unaware Consumers and Disclosure of Deficiencies

Stefanie Schmitt, Dominik Bruckner

We analyze firms' incentives to disclose deficiencies that reduce the quality of goods when consumers lack information. We distinguish two types of information: First, only some consumers are *aware* of the existence of deficiencies. Second, only some consumers have the *expertise* to infer the true levels of deficiencies once they are aware of the existence of deficiencies. We show that the interplay of awareness and expertise affects firms' incentives to disclose. In particular, an equilibrium where both firms remain silent can exist. In addition, we show that whether an increase in competition leads to more or less disclosure depends on the levels of awareness and expertise in the market. We highlight that the effectiveness of policy interventions depends on the composition of the consumer side.

Keywords: Awareness, Competition, Disclosure, Expertise, Product Quality.
JEL Codes: D83, L15.

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3.1 Introduction

Firms often remain silent, instead of disclosing deficiencies of their goods. For example, in 2020, a fraction of masks that were labeled as FFP2 failed the quality standard associated with FFP2 masks (see, e.g., Kümpel et al. 2020). Furthermore, goods often include unexpected substances that reduce the quality of the goods. For example, in several food scandals, unexpected substances, such as weed-killers, were discovered (see, e.g., Nelson 2017). Firms also remain silent about manipulation of food safety dates (see, e.g., Goodley 2017), manipulation of life span, or reductions in volume. In such situations, where firms remain silent about the deficiencies of their goods, consumers often lack the information about the deficiencies to make a fully informed consumption decision.

We propose a model about firms' incentives to disclose when the consumers are only partially informed about the goods' quality. We vary two dimensions of consumers' information, the awareness and the expertise of understanding the information. First, we analyze how consumers' awareness and expertise affect firms' incentives to disclose the true deficiencies of their goods. Second, we investigate the role of competition, i.e., whether increasing competition incentivizes firms to disclose. Third, we discuss the effectiveness of different policy interventions, i.e., to what extent different policies increase market transparency and ensure that consumers make a fully informed consumption decision.

To make a fully informed consumption decision, consumers need to be aware of all possible deficiencies that a good can exhibit. However, consumers are often unaware of the existence of possible deficiencies. For example, in the beginning of 2020, most consumers were unaware that many masks which where traded as FFP2 masks were deficient. Furthermore, sometimes consumers know that a deficiency could exist, but at the time of the consumption decision this knowledge does not come to mind, i.e., at the time of the decision, consumers lack the awareness.[1]

Besides awareness, consumers need a certain level of expertise to understand the true deficiency of goods. Depending on the good, the required expertise to understand the true deficiency implies a formal education, knowledge of a particular piece of information, or time to browse test reports. For example, to observe the deficiency of a used car, a formal education is helpful: A car mechanic is much more likely to understand the deficiency than an amateur. To check whether masks satisfy the FFP2 standards requires knowing that FFP2 masks are labeled and that it is possible to cross-check these labels. Lastly, to infer deficiencies of washing machines with regard to energy efficiency, consumers can invest time and effort to browse test reports and thus to observe the true energy efficiency of different washing machines. Yet, consumers who have the expertise to check goods for deficiency will not think to do so unless they are aware of the possibility of deficiencies. Thus, when consumers' lack awareness and/or expertise, to make a fully informed consumption decision, consumers are dependent on the firms disclosing these deficiencies.

Our objective is to analyze the incentives of firms to disclose their deficiencies if consumers

[1] Experimental and empirical evidence increasingly documents individuals' inattention during decision-making (see, e.g., Gabaix 2019, for an overview). For example, Chetty et al. (2009) show that although consumers are aware of the existence of sales taxes, they are inattentive to the tax at the time of the purchase.

lack awareness and expertise regarding these deficiencies. We assume that only a fraction of consumers considers the possibility of deficiencies; we call these consumers *aware*. The remaining consumers do not consider the possibility of deficiencies; they are *unaware*. In addition, once consumers are aware, some consumers are able to check the goods for the exact levels of deficiencies, i.e., these consumers are *experts*. The remaining consumers are unable to check the goods for the exact levels of deficiencies and have to build expectations, i.e., these consumers are *amateurs*. This distinction of consumers allows us to analyze the disclosing decision of firms in different markets. A firm can affect the distribution of aware and expert consumers in the market with its disclosure decision: If a firm discloses its deficiency, all consumers become aware that deficiencies exist. In addition, all consumers observe the true deficiency of the disclosing firm perfectly, i.e., all consumers become experts about the disclosing firm's deficiency.

In the main part of the article, we analyze the disclosure decision of two firms when deficiencies are exogenously given. This case captures the short term where firms cannot influence their level of deficiency. We show that an equilibrium exists in which both firms remain silent regarding their deficiencies. The existence of that equilibrium hinges on the fractions of aware and expert consumers. In particular, the relationship between awareness/expertise and disclosure is non-monotonic. Two effects motivate a firm to disclose. First, firms have a higher incentive to disclose, if consumers on average gain a more favorable impression of the disclosing firm's good. Second, firms have a higher incentive to disclose, if consumers on average gain a less favorable impression of the rival's good. Whether the average effect is beneficial depends on the awareness and expertise in the market. In addition, we highlight the role of competition and show that increasing competition does not necessarily lead to more market transparency: Whether increasing competition incentivizes firms to disclose depends on the composition of the consumer side.

These results show that firms do not always voluntarily disclose deficiencies of their goods. This leaves room for interventions by a market authority to raise transparency, i.e., to increase disclosure. We discuss the effects of information campaigns, facilitating competition, and the implementation of a minimum standard. We show that whether information campaigns, facilitating competition, or minimum standards are effective depends on the awareness and expertise in the market. Our results highlight the importance to account for awareness and expertise to assess the effectiveness of policy interventions.

In the long term, firms have sufficient time to adjust their investments to reduce deficiencies. Therefore, we extend the model to allow firms to invest in quality. We show that investments in quality and the probability of disclosure increase with the fraction of aware and expert consumers. An increase in the fraction of aware consumers implies that more consumers take the existence of deficiencies into account, which reduces their willingness to pay. As a consequence, firms would make lower profits. To avoid decreased profits, firms invest more to dispose of the deficiencies and disclose more favorable product information. Similarly, an increase in the fraction of expert consumers implies that more consumers take the true deficiencies into account instead of building expectations. Thus, firms invest in quality. Consequently, in the long term, policy interventions that increase the fraction of aware and/or expert consumers, such as information campaigns, are beneficial.

The effect of increasing competition on investments depends on the fraction of aware consumers relative to the fraction of experts. For a small fraction of aware consumers, the investment in quality and the probability to disclose is higher, the more intense the competition in a market: If most consumers are unaware of the existence of deficiencies, a monopolist has no incentive to invest to reduce deficiencies that consumers do not take into account. In contrast, duopolists have some incentive to invest to reduce their deficiencies, because this allows them to distinguish themselves from their competitor and increase their profits. In contrast, for a large fraction of aware consumers, the investment in quality and the probability to disclose is lower the more intense the competition in the market: If most consumers are aware of the existence of deficiencies, a monopolist has an incentive to invest to reduce deficiencies, because goods without deficiencies allow him to charge higher prices. In contrast, duopolists cannot fully extract these higher rents, because the competition decreases the prices. As a result, increasing competition can reduce an individual firm's incentive to invest in quality. As a consequence, a policy intervention that increases the competitive pressure in the market only induces firms to invest more if the fraction of aware consumers, relative to the fraction of expert consumers, is sufficiently low.

The remainder of the article is structured as follows. Section 3.2 discusses our contributions to the related literature. Section 3.3 introduces the model. In Section 3.4, we derive the market equilibria when deficiencies are exogenously given. In Section 3.5 we discuss different policy interventions and their influence on market transparency. In Section 3.6, we extend the model to analyze investments in quality, the probability to disclose, and different policy interventions. Section 3.7 concludes.

3.2 Related Literature

In his seminal article, Akerlof (1970) shows that asymmetric quality information between buyers and sellers can lead to adverse selection. However, adverse selection vanishes if firms can credibly and truthfully disclose quality information (Grossman & Hart 1980, Grossman 1981, Milgrom 1981, Milgrom & Roberts 1986, Okuno-Fujiwara et al. 1990): When firms remain silent, consumers cannot distinguish between high- and low-quality goods. Consequently, firms with above-average quality have an incentive to disclose their quality to distinguish themselves from their competitors which allows them to charge higher prices. Step by step, the market *unravels* until every firm (except the firm with the lowest quality) discloses its quality.

However, empirical and experimental evidence documents instances where this unraveling result breaks down (see, e.g., Mathios 2000, Jin 2005, Bederson et al. 2018, Sheth 2021). Models account for the breakdown of the unraveling result, for example, if disclosure is costly (Viscusi 1978, Jovanovic 1982, Jansen 2017), if consumers' tastes for quality and a horizontal characteristic of the good are correlated (Hotz & Xiao 2013), if firms have reputational concerns (Grubb 2011), if mandatory disclosure rules induce firms to acquire less information in the first place (Matthews & Postlewaite 1985, Shavell 1994, Polinsky & Shavell 2012), if signaling as an alternative means of communication is possible (Janssen & Roy 2015), or for product-use information (Bar-Gill & Board 2012). For an excellent survey see Dranove & Jin (2010).

Most articles that document a breakdown of the unraveling result focus on supply side reasons. Yet, the unraveling result hinges especially on the assumption that consumers are skeptical, i.e., that consumers assume the worst of a product whenever a firm remains silent. Ample evidence contests this assumption of fully rational and skeptical consumers (see, e.g., Brown et al. 2012, Szembrot 2018, Jin et al. 2021*a*,*b*). Evidence also accumulates that consumers neglect the existence of certain pieces of information (see, e.g., Chetty et al. 2009, Hanna et al. 2014).[2] As a consequence, we assume that not all consumers are aware of the existence of deficiencies and that some consumers who are aware are incapable of inferring the true deficiency. In addition, to capture the empirical and experimental evidence about imperfect skepticism and rationality (see, e.g., Brown et al. 2012, Szembrot 2018, Jin et al. 2021*a*,*b*), in the main part of the article, we focus on consumers who do no Bayesian updating. We include a version of the model with Bayesian updating in Appendix 3.8.2.

Thus, we first and foremost contribute to the disclosure literature with behavioral consumers. In this strand of the literature, disclosure has been shown to depend, for example, on the fraction of consumers who understand the disclosed information (Fishman & Hagerty 2003), on the fraction of consumers who are attentive to disclosed information and on the costs for searching for overlooked information (Ghosh & Galbreth 2013), on the extent to which consumers are skeptical about undisclosed information (Milgrom & Roberts 1986, Ispano & Schwardmann 2021), and on consumers' loss aversion (Zhang & Li 2021).[3] Hirshleifer et al. (2004) analyze a game where some players are inattentive to the disclosed information and some are not skeptical. However, in contrast to our model, all players are aware of the existence of the information. Hirshleifer et al. (2004) find that the unraveling result fails with limited attentive players. Li et al. (2014) focus on a duopoly where consumers are unaware of some characteristic of the goods and disclosure by one firm implies that all consumers become aware of the existence of that characteristic and the true level of that characteristic. Li et al. (2014) find full unraveling in fully covered markets. Li et al. (2016) analyze a model where only some consumers are aware of a potential deficiency, but no consumer initially knows the true deficiency level. Li et al. (2016) focuses on a monopoly where the firm can advertise to inform some consumers about the true level of deficiency. They show that a monopolist prefers to target advertising to aware consumers and that a larger fraction of aware consumers leads to more disclosure.

We contribute to this literature by extending the composition of the consumer side. We distinguish between aware and unaware consumers as well as expert and amateur consumers. We show that the interplay of the fraction of aware consumers and the fraction of expert consumers affects firms' disclosure decisions and the incentives of firms to invest in reducing deficiencies. By distinguishing between awareness and expertise, we provide a better understanding of the incentives that drive firms to disclose and on the conditions that determine the effectiveness of public policies.

Furthermore, we contribute to the debate whether more competition incentivizes or hampers disclosure. Stivers (2004), for example, finds positive effects of competition on disclosure, whereas, Cheong & Kim (2004), Board (2009), Guo & Zhao (2009), Levin et al. (2009), and Carlin et al. (2012) find negative effects of competition on disclosure. In contrast, we show that

[2]See Gabaix (2019) for an excellent overview of limited attention.

[3]The disclosure literature is closely related to the literature on shrouding of add-ons (see, e.g., Gabaix & Laibson 2010, Wenzel 2014, Heidhues et al. 2017).

whether competition has a positive or a negative effect on disclosure depends on the awareness and expertise of consumers.

3.3 Model

Consider a market where two firms, firm 1 and firm 2, compete for a unit mass of consumers. Firms produce goods with identical baseline quality v. However, the good of each firm $i \in \{1, 2\}$ may exhibit a deficiency $d_i \in (0, 1)$. The deficiencies of both firms are drawn by Nature from the same distribution. If the good of firm i exhibits a deficiency d_i, the quality of the good reduces to $v - d_i$. Alternatively, this setup can be interpreted as a situation where with probability ρ_i the deficiency does not occur, i.e., the deficiency is 0, and with the remaining probability $1 - \rho_i$ the deficiency does occur, i.e., the deficiency is 1. We assume identical marginal costs that we set to 0.

We assume the following standard linear-quadratic utility function for all consumers (Singh & Vives 1984):

$$U(x_1, x_2) = (v - d_1)x_1 + (v - d_2)x_2 - \frac{1}{2}(x_1^2 + 2\gamma x_1 x_2 + x_2^2) - p_1 x_1 - p_2 x_2, \tag{3.1}$$

where x_i is the quantity which consumers buy from firm $i \in \{1, 2\}$ at price p_i. The parameter $\gamma \in [0, 1]$ captures the substitutability between good 1 and good 2. If $\gamma = 0$, the goods are unrelated and both firms operate as monopolists; if $\gamma = 1$, the goods are perfect substitutes. We focus on the situation where firms sell to all consumers. Therefore, we assume $v > 2/(1 - \gamma)$.

We assume that not all consumers observe the deficiencies d_1 and d_2 perfectly or are even aware that goods can exhibits deficiencies. First, some consumers may be *aware* of the existence of deficiencies, while others are *unaware*. We denote the fraction of aware consumers by $\alpha \in (0, 1)$.

Second, only a fraction of consumers has the expertise to understand the true extent of the deficiency, i.e., these consumers are *experts*. In contrast, *amateurs* cannot observe the deficiencies of a good and thus can only build expectations $E[d_i] = E[d] \in (0, 1)$. We assume that amateurs are not necessarily skeptical of non-disclosure and do not update their beliefs according to Bayesian rule (we include a version with Bayesian updating in Appendix 3.8.2).[4] This allows us to analyze the effects of optimism (i.e., $E[d] < d_i$) and pessimism (i.e., $E[d] > d_i$). Nevertheless, if experts or amateurs are unaware, they completely disregard the deficiency. We denote the fraction of experts by $\chi \in (0, 1)$.

Consequently, dependent on their awareness and expertise, consumers differ with respect to their perception of d_i. We denote the perceived deficiency by $\hat{d}_i$. We distinguish four groups of consumers (see Table 3.1): A fraction $\alpha\chi$ of consumers are experts who are aware of deficiencies. These consumers observe the deficiencies perfectly, i.e., $\hat{d}_i = d_i$. A fraction $\alpha(1-\chi)$ are amateurs who are aware of deficiencies. These consumers know that the goods can exhibit deficiencies,

[4] Bayesian updating and the assumption of extreme skepticism play an important role in the literature (see, e.g., Grossman & Hart 1980, Grossman 1981, Milgrom 1981, Okuno-Fujiwara et al. 1990). Yet, empirical and experimental evidence documents that individuals deviate from Bayesian updating in many situations (see, e.g., Brown et al. 2012, Szembrot 2018, Jin et al. 2021*a*,*b*). In this paper, our focus lies on such consumers who do not use Bayesian updating and who are not necessarily skeptical.

but lack the expertise to check the goods for their true level of deficiency. Thus, these consumers build expectations, i.e., $\hat{d}_i = E[d_i] = E[d]$. A fraction $(1-\alpha)\chi$ are unaware experts, who are capable of checking the exact level of deficiency but do not know that deficiencies exist. A fraction $(1-\alpha)(1-\chi)$ are unaware amateurs who are both incapable of checking the level of deficiency and unaware of the existence of deficiencies. As long as unaware consumers stay uninformed about the existence of deficiencies, unaware experts and unaware amateurs behave exactly the same. Therefore, all unaware consumers perceive $\hat{d}_i = 0$.

	χ experts	$1-\chi$ amateurs
α aware	$\hat{d}_i = d_i$	$\hat{d}_i = E[d]$
$1-\alpha$ unaware	$\hat{d}_i = 0$	$\hat{d}_i = 0$

Table 3.1: Overview of consumers types and their perceived deficiencies $\hat{d}_i$.

Although, the *experienced* utility given in Equation (3.1) is the same for all consumers, consumers differ with respect to their *perceived* utility. In the perceived utility, consumers use their perceived deficiencies, $\hat{d}_1$ and $\hat{d}_2$, instead of the true deficiencies d_1 and d_2:

$$\hat{U}(x_1, x_2) = (v - \hat{d}_1)x_1 + (v - \hat{d}_2)x_2 - \frac{1}{2}(x_1^2 + 2\gamma x_1 x_2 + x_2^2) - p_1 x_1 - p_2 x_2. \tag{3.2}$$

A consumer's demand for the goods is given by maximizing the perceived utility. Therefore, the demand of a consumer is:[5]

$$x_i(p_i, p_j) = \frac{v(1-\gamma) - \hat{d}_i - p_i + \gamma(\hat{d}_j + p_j)}{1-\gamma^2}.$$

As consumers differ in their perception of deficiencies, consumers differ in their maximum willingness to pay and, consequently, in their demand. Thus, the total demand for the good of a firm depends on the composition of the consumer side. Firms are perfectly aware of the composition of the consumer side, but do not observe to which specific fraction individual consumers belong.

Figure 3.1 illustrates the timing of our model. We assume that firms' deficiencies are drawn by Nature and that firms observe the deficiency of their competitor perfectly. Then, firms play a two-stage game: In the first stage, firms decide whether to disclose the deficiencies of their goods or remain silent. We do not assume any costs for disclosure. By disclosing, a firm influences α and χ. If a firm discloses its deficiency, all consumers become aware that deficiencies can exist, i.e., $\alpha = 1$. This shift in awareness α implies that the disclosing firm inflicts an externality on its competitor. In addition, all consumers become experts about the deficiency of the disclosing firm. Thus, if firm i discloses: $\hat{d}_i = d_i$ for all consumers. In the second stage, after observing the disclosure decision of their competitor, firms choose prices. Afterwards, consumers make their consumption decision.

[5] Theoretically, the demand would become zero if firm i chooses a price $p_i > v(1-\gamma) - \hat{d}_i + \gamma(\hat{d}_j + p_j)$. However, in equilibrium, firms will always choose prices such that both firms will face a positive demand.

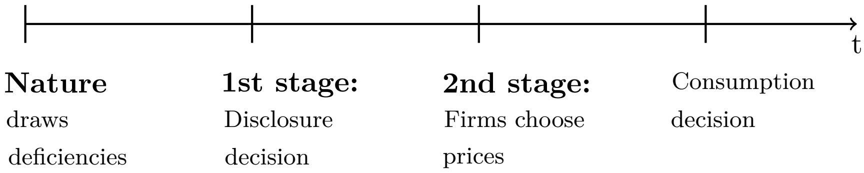


Figure 3.1: Timeline.

3.4 Results

We solve for the pure-strategy subgame-perfect Nash equilibria by backward induction.

3.4.1 Price-setting

In the price-setting stage, firms simultaneously and independently choose prices to maximize their profits. As the profit of each firm depends on the disclosure decisions in the preceding stage, we distinguish three types of subgames: one subgame where neither firm discloses its deficiency, one subgame where only one firm discloses, and one subgame where both firms disclose.

First, if both firms remain silent (S), a fraction $\alpha\chi$ of consumers observes d_1 and d_2 perfectly, a fraction $\alpha(1-\chi)$ builds expectations about d_1 and d_2, and the remaining consumers do not take the deficiencies into account. Consequently, the profit of firm $i \in \{1,2\}$ equals:

$$\begin{aligned}\pi_i^{SS}(p_i,p_j) &= x_i^{SS}(p_i,p_j) \times p_i \\ &= (\alpha\chi\frac{v(1-\gamma)-d_i-p_i+\gamma(d_j+p_j)}{1-\gamma^2} \\ &\quad + \alpha(1-\chi)\frac{v(1-\gamma)-E[d]-p_i+\gamma(E[d]+p_j)}{1-\gamma^2} \\ &\quad + (1-\alpha)\frac{v(1-\gamma)-p_i+\gamma p_j}{1-\gamma^2}) \times p_i.\end{aligned}$$

Firm $i \in \{1,2\}$ chooses its price p_i to maximize its profit. Therefore, in the subgame where both firms remain silent, by symmetry, firm $i \in \{1,2\}$ chooses price:

$$p_i^{SS} = \frac{v(2-\gamma-\gamma^2)-\alpha\chi(2-\gamma^2)d_i+\alpha\chi\gamma d_j-\alpha(1-\chi)(2-\gamma-\gamma^2)E[d]}{4-\gamma^2}. \tag{3.3}$$

The corresponding profit of firm $i \in \{1,2\}$ is:

$$\pi_i^{SS} = \frac{\left(p_i^{SS}\right)^2}{1-\gamma^2}.$$

Second, if only one firm discloses its deficiency, all consumers observe the deficiency of that firm perfectly. Furthermore, as soon as one firm makes its deficiency public, all consumers become aware of the existence of deficiencies, i.e., $\alpha = 1$. Yet, only a fraction χ, i.e., experts, observes the deficiency of the other firm perfectly; amateurs, $1-\chi$, build expectations. Let firm i be the disclosing firm (D) and let its competitor $j \neq i$ remain silent (S). Then, the profit of firm i is:

$$\pi_i^{DS}(p_i, p_j) = x_i^{DS}(p_i, p_j) \times p_i = \frac{v(1-\gamma) - p_i - d_i + \gamma\big(\chi d_j + (1-\chi)E[d] + p_j\big)}{1-\gamma^2} \times p_i.$$

In contrast, the profit of firm $j \neq i$ is:

$$\pi_j^{DS}(p_i, p_j) = x_j^{DS}(p_i, p_j) \times p_j = \frac{v(1-\gamma) - p_j - \big(\chi d_j + (1-\chi)E[d]\big) + \gamma(d_i + p_i)}{1-\gamma^2} \times p_j.$$

Firms maximize their profits, yielding the following equilibrium prices:

$$p_i^{DS} = \frac{v(2-\gamma-\gamma^2) - (2-\gamma^2)d_i + \gamma\big(\chi d_j + (1-\chi)E[d]\big)}{4-\gamma^2}, \tag{3.4}$$

$$p_j^{DS} = \frac{v(2-\gamma-\gamma^2) + \gamma d_i - (2-\gamma^2)\big(\chi d_j + (1-\chi)E[d]\big)}{4-\gamma^2}. \tag{3.5}$$

The corresponding profits when only firm i discloses are:

$$\pi_i^{DS} = \frac{\left(p_i^{DS}\right)^2}{1-\gamma^2},$$

$$\pi_j^{DS} = \frac{\left(p_j^{DS}\right)^2}{1-\gamma^2}.$$

Third, if both firms disclose their deficiencies, all consumers observe d_1 and d_2 perfectly, i.e., $\alpha = 1$ and $\chi = 1$, and the profit of firm $i \in \{1, 2\}$ is:

$$\pi_i^{DD}(p_i, p_j) = x_i^{DD}(p_i, p_j) \times p_i = \frac{v(1-\gamma) - p_i - d_i + \gamma(d_j + p_j)}{1-\gamma^2} \times p_i.$$

By symmetry, firm $i \in \{1, 2\}$ chooses price:

$$p_i^{DD} = \frac{v(2-\gamma-\gamma^2) - (2-\gamma^2)d_i + \gamma d_j}{4-\gamma^2}. \tag{3.6}$$

The corresponding profit of firm $i \in \{1, 2\}$ is thus:

$$\pi_i^{DD} = \frac{\left(p_i^{DD}\right)^2}{1-\gamma^2}.$$

3.4.2 Disclosure Decision

In the disclosure stage, firms decide simultaneously and independently whether to disclose. They either disclose their true deficiency or remain silent. Table 3.2 illustrates the reduced game of the firms in the disclosure stage.

		Firm 2 *Disclose*	Firm 2 *Silent*
Firm 1	*Disclose*	π_1^{DD}, π_2^{DD}	π_1^{DS}, π_2^{DS}
	Silent	π_1^{SD}, π_2^{SD}	π_1^{SS}, π_2^{SS}

Table 3.2: Game matrix of the disclosure decision.

Four different subgame-perfect equilibria are possible: one where neither firm discloses, (S,S); two where only one firm discloses, (S,D) or (D,S); and one where both firms disclose, (D,D). Proposition 2 summarizes the existence conditions for each equilibrium.

Proposition 2 (Subgame-perfect Nash equilibria)
(i) There exists a subgame-perfect Nash equilibrium where both firms disclose and choose prices given in (3.6) *if for all* $i \in \{1,2\}$

$$d_i \leq E[d].$$

(ii) There exists a subgame-perfect Nash equilibrium where firm $i \in \{1,2\}$ *discloses, firm* $j \in \{1,2\}$ *with* $i \neq j$ *remains silent, and firms choose prices given in* (3.4) *and* (3.5) *if*

$$d_j \geq E[d] \text{ and } d_i(2-\gamma^2)(1-\alpha\chi) - d_j\gamma\chi(1-\alpha) \leq E[d](1-\chi)(\alpha(2-\gamma-\gamma^2)+\gamma).$$

(iii) There exists a subgame-perfect Nash equilibrium where both firms remain silent and choose prices given in (3.3) *if for all* $i, j \in \{1,2\}$ *and* $i \neq j$

$$d_i(2-\gamma^2)(1-\alpha\chi) - d_j\gamma\chi(1-\alpha) \geq E[d](1-\chi)(\alpha(2-\gamma-\gamma^2)+\gamma).$$

The proof is in the Appendix. Proposition 2 shows that, in contrast to the unraveling result, we also find situations where neither firm discloses. The market unravels fully, i.e., both firms disclose, if consumers are pessimistic, i.e., $d_i \leq E[d]$ for all $i \in \{1,2\}$. This means, if $d_i \leq E[d]$ for all $i \in \{1,2\}$, neither firm has an incentive to unilaterally deviate from disclosing to remaining silent. If both firms disclose, all consumers observe the deficiencies of both firms perfectly. If firm $i \in \{1,2\}$ instead deviates to remaining silent, all consumers are still aware of the existence of deficiencies and perfectly observe the disclosing firm's deficiency. Thus, by remaining silent, a firm only affects the amateurs' perceived deficiencies of its own good. If the firm discloses, amateurs perceive the true deficiency. If the firm remains silent, amateurs build expectations about the deficiency. As $d_i \leq E[d]$ for all $i \in \{1,2\}$, amateurs have a lower willingness to pay (WTP) for the good of firm i, when firm i remains silent and firm $j \neq i$ discloses compared to when both firms disclose. Consequently, neither firm has an incentive to unilaterally deviate from disclosing and a subgame-perfect equilibrium exists where both firms disclose.

However, the subgame-perfect Nash equilibrium in which both firms disclose need not be unique. Panel (a) of Figure 3.2 illustrates a situation where, for $d_i \leq E[d]$ for all $i \in \{1,2\}$, a second subgame-perfect Nash equilibrium exists in which both firms remain silent, if α is sufficiently low relative to χ. If both firms remain silent, aware experts perceive the true deficiencies of both firms, aware amateurs build expectations, and all unaware consumers perceive no deficiency. If firm i unilaterally deviates and discloses, aware amateurs and all unaware consumers receive more information and perceive the deficiency of firm i perfectly, i.e., $\hat{d}_i = d_i$. Consequently, they adjust their WTP. On the one hand, aware amateurs, i.e., a fraction $\alpha(1-\chi)$ of consumers, adjust their WTP upwards as $d_i \leq E[d]$. On the other hand, unaware consumers, i.e., a fraction $(1-\alpha)$ of consumers, adjust their WTP downwards as $d_i > 0$.[6] If α is low relative to χ, the second effect dominates such that the firms have no incentive to deviate from remaining silent. Thus, if $d_i \leq E[d]$ for all $i \in \{1,2\}$ and α is sufficiently low relative to χ, a second subgame-perfect equilibrium exists in which both firms remain silent.

If $d_i > E[d]$ for at least one firm $i \in \{1,2\}$, either one firm remains silent and one firm discloses or both firms remain silent. These subgame-perfect Nash equilibria are unique. Panel (b) of Figure 3.2 depicts such a situation. For sufficiently low α relative to χ both firms remain silent; otherwise, the firm with the lower deficiency discloses. The existence of each equilibrium depends on the adjustment of the WTP. The firm with the higher deficiency never has an incentive to disclose because disclosure decreases the WTP of all unaware consumers ($d_i > 0$) and of all aware amateurs ($d_i > E[d]$) and, therefore, reduces the firm's profits. In addition, a comparison with its competitor hurts the firm with the higher deficiency if it discloses.

If the firm with the lower deficiency discloses, the WTP of unaware consumers decreases ($d_i > 0$). The WTP of aware amateurs increases if $d_i < E[d]$ and decreases if $d_i > E[d]$. Aware experts' WTP is unaffected. In addition, by disclosing the firm educates consumers about the deficiency of its competitor. Former unaware experts are now perfectly aware of both deficiency levels. Former unaware amateurs now build expectations about the silent firm's deficiency. Thus, disclosure not only exerts a negative externality on the opponent silent firm but also reduces the negative adjustment effect on the WTP of unaware consumers for the disclosing firm. Therefore, both firms remain silent if both deficiencies are similarly high. Panels (c) and (d) of Figure 3.2 highlight this.

In the following, we focus on the conditions for the existence of the subgame-perfect equilibrium where both firms remain silent. We analyze the effects of different deficiencies as well as the composition of the consumer side on the existence of this equilibrium. In addition, we analyze how increased competition influences firms' incentives to remain silent.

3.4.3 Comparative Statics

Note that both firms remain silent if

$$d_1(2-\gamma^2)(1-\alpha\chi) - d_2\gamma\chi(1-\alpha) \geq E[d](1-\chi)\big(\alpha(2-\gamma-\gamma^2)+\gamma\big) \tag{3.7}$$

and

$$d_2(2-\gamma^2)(1-\alpha\chi) - d_1\gamma\chi(1-\alpha) \geq E[d](1-\chi)\big(\alpha(2-\gamma-\gamma^2)+\gamma\big). \tag{3.8}$$

[6] Unaware experts now also perceive the deficiency of the silent firm perfectly. Unaware amateurs build expectations about the silent firm's deficiency. This also affects the willingness to pay for the disclosing firm's good.

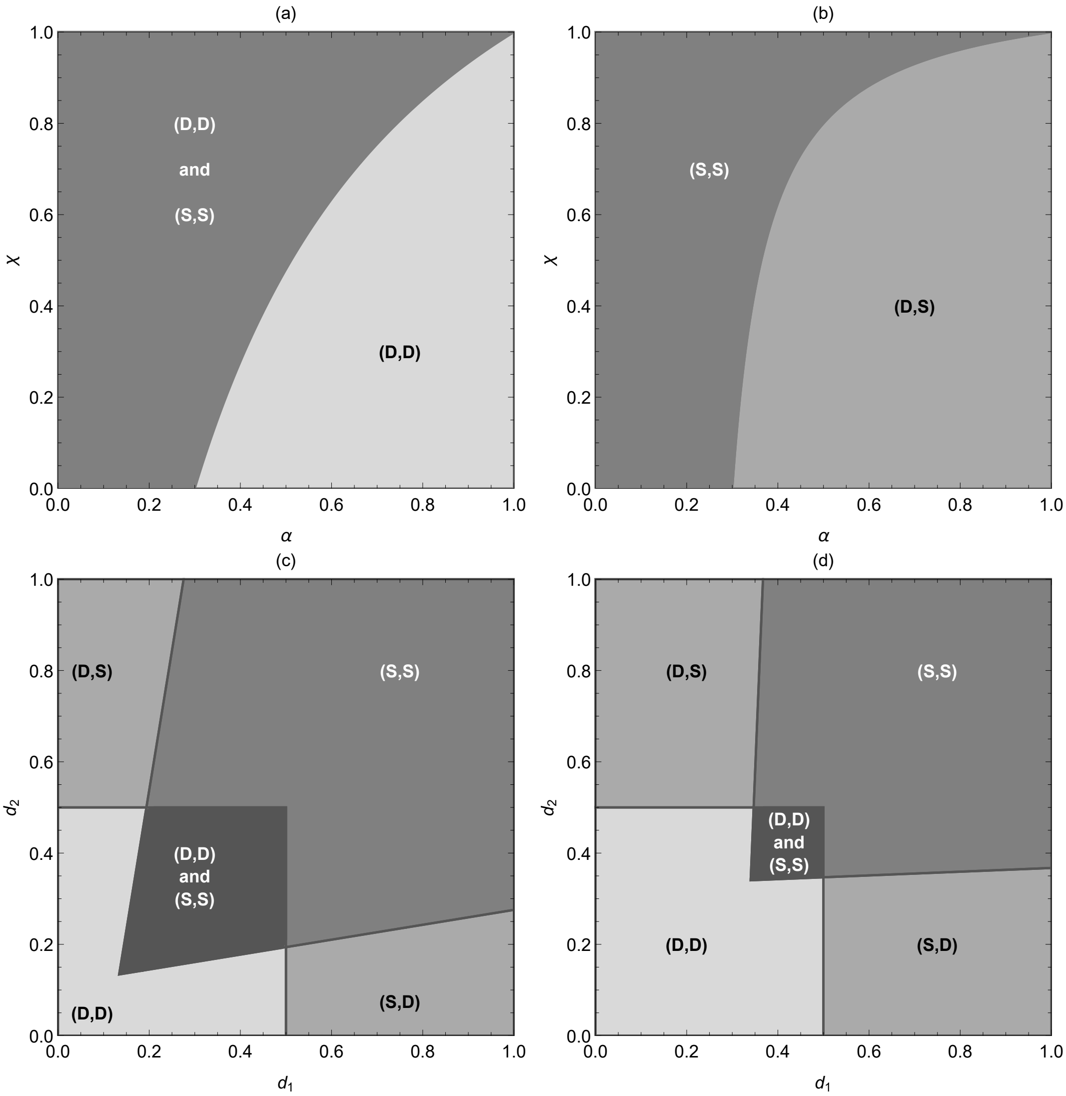


Figure 3.2: Disclosure decisions with $E[d] = 1/2$ and $\gamma = 1/2$. For (a): $d_1 = 1/4$ and $d_2 = 1/3$. For (b): $d_1 = 1/4$ and $d_2 = 3/4$. For (c): $\alpha = 1/3$ and $\chi = 2/3$. For (d): $\alpha = 2/3$ and $\chi = 1/3$.

If $d_1 \leq d_2$, (3.7) is binding. Otherwise (3.8) is binding. Without loss of generality, in the following we assume $d_1 \leq d_2$ and let

$$\tau \equiv d_1(2-\gamma^2)(1-\alpha\chi) - d_2\gamma\chi(1-\alpha) - E[d](1-\chi)\big(\alpha(2-\gamma-\gamma^2)+\gamma\big).$$

Then, Proposition 2 (*iii*) holds if $\tau \geq 0$. The existence condition, i.e., $\tau \geq 0$, is derived from a comparison of the profits of firm 1 when both firms remain silent and when only firm 1 discloses. τ increases if the profit of firm 1 for remaining silent increases compared to its profit when it discloses.

Actual and expected deficiencies

The existence of a subgame-perfect equilibrium where both firms remain silent depends on the firms' actual deficiencies as well as the expected deficiencies.

First, the range of values for which both firms remain silent increases, if the deficiency of the firm with the binding constraint increases:

$$\frac{\partial \tau}{\partial d_1} = (2-\gamma^2)(1-\alpha\chi) > 0.$$

If firm 1 discloses, all consumers will take the true deficiency of firm 1 into account. The higher the deficiency of firm 1, the lower the WTP for the good of firm 1. Thus, the higher d_1, the less firm 1 profits from disclosing.

Second, the range of values for which both firms remain silent decreases, if the deficiency of the firm with the higher deficiency increases:

$$\frac{\partial \tau}{\partial d_2} = -\gamma\chi(1-\alpha) \leq 0.$$

If firm 1 discloses, more consumers will take the true deficiency of firm 2 into account. Former unaware experts now know the true deficiency. The higher the deficiency of firm 2, the higher the WTP for the good of firm 1. Thus, the higher d_2, the more firm 1 profits from disclosing.

Third, the range of values for which both firms remain silent decreases in the expected deficiency, $E[d]$:

$$\frac{\partial \tau}{\partial E[d]} = -(1-\chi)\big(\alpha(2-\gamma-\gamma^2)+\gamma\big) < 0.$$

If both firms remain silent, an increase in $E[d]$ implies that aware amateurs' WTP decreases. In other words, aware amateurs become more pessimistic towards the deficiencies of good 1 *and* good 2. In contrast, if firm 1 discloses, all consumers observe the true deficiency of firm 1 and amateurs build expectations only about the good of firm 2. Then, an increase in $E[d]$ increases the WTP for the good of firm 1. In sum, if $E[d]$ increases, firm 1 discloses for a larger range of values. This effect can be attributed to changes in pessimism: The more pessimistic consumers are towards firms, the more transparent firms become.

Consumer types

The existence of the equilibrium, where both firms remain silent, also hinges on the fraction of aware and expert consumers in the market. In general, an increase in awareness has the subsequent effect on τ:

$$\frac{\partial \tau}{\partial \alpha} = -(2-\gamma^2)\left(\chi d_1 + (1-\chi)E[d]\right) + \gamma\left(\chi d_2 + (1-\chi)E[d]\right). \tag{3.9}$$

If both firms remain silent, an increase in α affects the WTP for good 1 in four ways: First, if α increases, more consumers observe d_1 perfectly which decreases the average WTP for the good of firm 1. Second, if α increases, more consumers build expectations about the deficiency of firm 1 and, as $E[d] > 0$, this decreases the average WTP for the good of firm 1. Third, if α increases, more consumers observe d_2 perfectly which increases the average WTP for the good of firm 1. Fourth, if α increases, more consumers build expectations about the deficiency of firm 2 and, as $E[d] > 0$, this increases the average WTP for the good of firm 1. Whether in sum, the WTP for the good of firm 1 increases or decreases depends on the substitutability between the goods, γ. If $\gamma \to 0$, only the effects on d_1 and on the expectations about d_1 matter. If $\gamma \to 1$, the effects on the deficiencies (actual and expected) of firm 1 and firm 2 carry equal weight. In sum, for low levels of substitutability, the motivation to inform consumers about its own quality affects firm 1's decision to disclose. For high levels of substitutability, the decision of firm 1 to disclose is also affected by the motivation to inform consumers about its rival's quality.

In contrast, if firm 1 discloses and firm 2 remains silent, an increase in the initial fraction of aware consumers has no effect, because the disclosure already yields full awareness.

Corollary 1 summarizes this:[7]

Corollary 1
There exists a γ' such that

(i) $\partial\tau/\partial\alpha < 0$ if and only if $\gamma < \gamma'$ and

(ii) $\partial\tau/\partial\alpha > 0$ if and only if $\gamma > \gamma'$.

The fraction of experts χ also affects firms' incentives to disclose:

$$\frac{\partial \tau}{\partial \chi} = -d_1(2-\gamma^2)\alpha - d_2\gamma(1-\alpha) + E[d](\alpha(2-\gamma-\gamma^2)+\gamma). \tag{3.10}$$

If both firms remain silent, an increase in χ has the following effects on the WTP for the good of firm 1 and thus also on the profit of firm 1: First, as χ increases, more consumers observe the true deficiency of firm 1 instead of building expectations about d_1. This increases (decreases) the WTP for the good of firm 1, if $d_1 < E[d]$ ($d_1 > E[d]$). Second, as χ increases, more consumers observe the true deficiency of firm 2, instead of building expectations about d_2. This increases (decreases) the WTP for the good of firm 1, if $d_2 > E[d]$ ($d_2 < E[d]$). In addition, the fraction of aware consumers affects how pronounced the changes in WTP are: The higher α, the more pronounced are the changes in WTP when both firms remain silent.

[7] See Appendix 3.8.3 for a detailed derivation.

In contrast, if only firm 1 discloses and χ increases, more consumers observe the true deficiency of firm 2, instead of building expectations about d_2. This increases (decreases) the WTP, if $d_2 > E[d]$ ($d_2 < E[d]$).

Then, τ increases if the profit of firm 1 for remaining silent increases compared to its profit when it discloses. Corollary 2 summarizes the effect of χ on τ:[8]

Corollary 2
There exists a α' such that

(i) $\partial\tau/\partial\chi < 0$ if and only if $E[d] < d_1 < d_2$ or $d_1 < E[d] < d_2$ with $\alpha < \alpha'$ and

(ii) $\partial\tau/\partial\chi > 0$ if and only if $d_1 < E[d] < d_2$ with $\alpha > \alpha'$ or $d_1 < d_2 < E[d]$.

Competitive pressure

The parameter γ captures the substitutability between good 1 and good 2. If $\gamma = 0$, the goods are unrelated and both firms operate as monopolists; if $\gamma = 1$, the goods are perfect substitutes. Thus, γ measures the *competitive pressure* and is essential for a policy analysis.

The impact of competitive pressure on τ is:

$$\frac{\partial\tau}{\partial\gamma} = -2\gamma d_1(1-\alpha\chi) - \chi d_2(1-\alpha) + E[d](1-\chi)(\alpha(1+2\gamma)-1). \tag{3.11}$$

Increasing competition does not always reduce the range of values for which both firms remain silent. The effect depends on the deficiencies and the composition of the consumer side. Increasing the competitive pressure has two main effects.

First, as γ increases, consumers put more weight on d_2 relative to d_1. This increases the WTP for the good of firm 1 if both firms remain silent as well as when only firm 1 discloses. However, the effect is more pronounced when firm 1 discloses, because when both firms remain silent only aware experts take d_1 and d_2 into account. In consequence, this effect incentivizes firm 1 to disclose.

Second, if both firms remain silent, a fraction $\alpha(1-\chi)$ of consumers builds expectations about the deficiencies of firm 1 and firm 2 such that $E[d_1] = E[d_2]$. If $\gamma = 0$, consumers' WTP for the good of firm 1 is independent of the expected deficiency of firm 2. Whereas, if $\gamma = 1$, consumers' WTP for the good of firm 1 depends equally on the expected deficiencies of good 1 and good 2. Thus, as γ increases the expected deficiencies become less important such that the WTP for the good of firm 1 increases. In contrast, if firm 1 discloses, all consumers observe the deficiency of firm 1 perfectly, only amateurs build expectations about the deficiency of firm 2. An increase in γ then benefits firm 1. This second effect incentivizes firm 1 to remain silent if α is sufficiently large.

In sum, for a sufficiently high α, the range of values for which both firms remain silent may increase. That means, if a large fraction of consumers is aware, high competitive pressure is not optimal. Corollary 3 summarizes this:[9]

[8] See Appendix 3.8.3 for a detailed derivation.
[9] See Appendix 3.8.3 for a detailed derivation.

Corollary 3
There exists a α'' such that

(i) $\partial\tau/\partial\gamma < 0$ *if and only if* $E[d] < d_1$ *or* $E[d] > d_1$ *with* $\alpha < \alpha''$ *and*

(ii) $\partial\tau/\partial\gamma > 0$ *if and only if* $E[d] > d_1$ *with* $\alpha > \alpha''$.

3.5 Policy Implications

Market authorities aim to achieve a high level of market transparency in order to ensure that consumers can make fully informed consumption decisions. In our model, this translates to all firms disclosing their product information. Yet, as our results show the unraveling result does not always hold (see Proposition 2). Dependent on the fraction of aware and expert consumers, firms find it optimal to remain silent. This leaves room for policy interventions from market authorities to increase market transparency.

The strictest intervention to implement by a market authority is a mandatory label where firms always have to disclose their deficiencies. In our model, this intervention eliminates all equilibria except full disclosure. In the following, we discuss the effects of information campaigns, facilitating competition, and a minimum standard.

3.5.1 Information Campaign

One possible intervention that market authorities regularly use is an information campaign. Information campaigns apply to two features of our model: First, information campaigns attract consumers' awareness to a particular topic and inform consumers of the possibility of deficiencies, i.e., they increase α. Second, information campaigns can increase the fraction of experts in the market, i.e., they increase χ.

To increase awareness in a market, the market authority can place advertisements. Voluntary labels and certificates can also increase the awareness of consumers. One recent example is the "green button" that the German federal government implemented. This campaign aims to increase awareness towards sustainable and ecological products in the fashion industry. In addition to inventing the voluntary label, the German federal government placed advertisements highlighting the role of sustainable products. Furthermore, the introduction of new labels is often discussed in the media and therefore further increases awareness among consumers. An information campaign can also increase the fraction of experts χ in the market. Examples of such information campaigns include advertising of information or advanced scientific training.

Information campaigns have a direct and an indirect effect. Information campaigns directly increase the fractions of consumers who make a fully informed decision. Information campaigns also indirectly affect firms' incentives to disclose. This indirect effect is relevant as information campaigns often do not reach all consumers. The consumers who do not directly benefit from the information campaign are still dependent on firms' disclosure.

Whether an increase in awareness incentivizes firms to disclose, i.e., $(\partial\tau)/(\partial\alpha) < 0$, depends on the competitive pressure within the market, i.e., γ: According to Corollary 1, an information campaign increases the incentive to disclose, if the competitive pressure in the market is sufficiently low. An information campaign that increases the fraction of experts χ in the market increases the incentives to disclose if consumers are optimistic or if consumers are partially optimistic and α is sufficiently low (see Corollary 2).

3.5.2 Facilitating Competition

The market authority can also intervene by facilitate competition, for example, by enforcing antitrust laws or dismantling entry barriers. In addition, the use of information campaigns, in particular labels and certificates, may facilitate competition among firms. For example, a market authority can restrict the number of voluntary labels or certificates such that firms must not use any other label than the voluntary label implemented by the market authority if they want to disclose their deficiency. Thereby, a market authority establishes one platform for firms' disclosure and thus increases competition by increasing the comparability of products. This prevents firms from avoiding competition by pretending to sell differentiated goods.

The effect of facilitated competition on the market outcome, i.e., $(\partial\tau)/(\partial\gamma)$, depends on the fraction of aware consumers relative to the fraction of expert consumers in the market (see Corollary 3). Facilitating competition, i.e., an increase in γ, only increases disclosure if consumers are optimistic or if the fraction of aware consumers is sufficiently low. Otherwise, facilitating competition increases the incentives of firms to remain silent.

3.5.3 Minimum Standard

A market authority can also target the supply side directly, for example, by introducing a minimum standard. A market authority can restrict market access to firms with deficiencies $d_i < \bar{d}$. Therefore, a minimum standard affects $d_1, d_2 \in [0, \bar{d}]$. This measure prevents firms from selling any good with deficiency $d_i > \bar{d}$. Additionally, by implementing $\bar{d}$ the distribution regarding consumers' expectations shift downwards, i.e., $E[d]_{new} < E[d]_{old}$. As $(\partial\tau)/(\partial E[d]) < 0$, this change in expectations decreases the range of values for which a transparent market outcome occurs (see Section 3.4.3).

3.6 Extension: Investments in Quality

3.6.1 Investment Decision

In this section, we allow firms to invest in quality. In particular, we allow firms to invest to eliminate the deficiency of their good. Yet, in line with the interpretation of the probabilistic occurrence of deficiencies not all investments are successful. Each firm can invest $\rho_i \in [0, 1]$ to obtain deficiency $d_i = 0$ with probability ρ_i and deficiency $d_i = 1$ with probability $1 - \rho_i$. If a firm invests ρ_i, it incurs costs $C(\rho_i) = c\rho_i^2$ with $c > 0$. We assume that consumers remain oblivious to the investment decisions of the firms.

Firms now play a three-stage game (see Figure 3.3): In the first stage, both firms choose their investment ρ_i. In the second stage, after observing the investment of their competitor each firm decides whether to disclose. In the third stage, both firms choose prices. The solution of the price-setting and the disclosure decision are identical to Section 3.4.

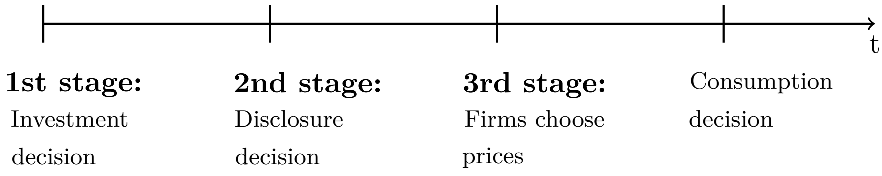


Figure 3.3: Timeline.

In the first stage, both firms consider the four possible outcomes of the investment decisions: (i) both firms' deficiencies are 0, (ii) and (iii) one firm's deficiency is 0 and the other firm's deficiency is 1, and (iv) both firms' deficiencies are 1. The profit of firm $i \in \{1, 2\}$ is thus:

$$\begin{aligned}\pi_i(\rho_i, \rho_j) = &\rho_i\rho_j \times \pi_i(0,0) + \rho_i(1-\rho_j) \times \pi_i(0,1) + (1-\rho_i)\rho_j \times \pi_i(1,0) \\ &+ (1-\rho_i)(1-\rho_j) \times \pi_i(1,1) - C(\rho_i).\end{aligned}$$

It follows from Proposition 2 that each possible combination of deficiencies, i.e., (d_i, d_j) with $d_i \in \{0, 1\}$ and $d_j \in \{0, 1\}$, leads to one specific disclosure outcome. If both firms obtain low deficiencies, $d_1 = d_2 = 0$, Proposition 2 (i) is fulfilled and both firms disclose. If both deficiencies are high, $d_1 = d_2 = 1$, Proposition 2 (iii) is fulfilled and neither firm discloses. If the deficiency levels differ, Proposition 2 (ii) is fulfilled and the firm with the higher deficiency remains silent and the firm with the lower deficiency discloses. Accordingly, the profit function of firm $i \in \{1, 2\}$ reduces to:

$$\pi_i(\rho_i, \rho_j) = \rho_i\rho_j\pi_i^{DD} + \rho_i(1-\rho_j)\pi_i^{DS} + (1-\rho_i)\rho_j\pi_i^{SD} + (1-\rho_i)(1-\rho_j)\pi_i^{SS} - C(\rho_i).$$

Each firm i chooses ρ_i to maximize its profit. Proposition 3 summarizes the optimal investment choice.

Proposition 3 (Investment)
Let

$$\begin{aligned}\bar{\chi} &\equiv \chi + (1-\chi)E[d], \\ \bar{\gamma} &\equiv= 2 - \gamma - \gamma^2.\end{aligned}$$

In the subgame-perfect Nash equilibrium, for all $i \in \{1, 2\}$:

$$\rho_i^* = min\left\{\frac{2v\bar{\chi}\bar{\gamma}(\gamma + \alpha\bar{\gamma}) + \bar{\chi}^2(\gamma^2 - \alpha^2\bar{\gamma}^2)}{2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}\bar{\gamma}^2(2v(1-\alpha) + \alpha^2\bar{\chi}) + \bar{\chi}^2(\gamma^2 + (2-\gamma^2)^2)}, 1\right\}.$$

The proof of Proposition 3 is in the Appendix. In equilibrium, both firms choose ρ_i^*. ρ_i^* is the probability that a firm produces goods with low deficiencies 0 and discloses.

The left panel of Figure 3.4 shows the investment ρ_i^* as a function of the initial fraction of aware consumers α for different values of γ. Generally, ρ_i^* is increasing in α.[10] If at least one firm produces a good without deficiency, that firm discloses and all consumers become aware

[10] See Appendix 3.8.5 for a detailed analysis of $(\partial\rho_i^*)/(\partial\alpha)$.

of the possibility of deficiencies, i.e., $\alpha = 1$. In these cases, a change in the original fraction of aware consumers has no effect on the firms' profits. The original fraction of aware consumers α affects firms' profits only if both firms produce goods with deficiencies and remain silent. Then, an increase in α implies a reduction in the average willingness to pay of the consumers: For former unaware consumers the perceived deficiency becomes either $\hat{d}_i = d_i > 0$ or $\hat{d}_i = E[d] > 0$ instead of $\hat{d}_i = 0$. Consequently, firms choose lower prices and make less profit. To counter this reduction in profits, firms increase their investment ρ_i such that the outcome $(Silent, Silent)$ becomes less likely. Therefore, an increase in α leads to an increase in ρ_i^*.

Firms invest more if the fraction of experts χ in the market increases (see the right panel of Figure 3.4).[11] Two effects play a role here. First, an increase in χ reduces the profit of firm i if firm i produces a deficiency $d_i = 1$ and remains silent: An increase in χ implies that more consumers observe the true deficiency instead of building expectations, which reduces consumers' average willingness to pay. Consequently, firm i has an incentive to avoid these cases by investing more. Second, an increase in χ increases the profit of firm i if its deficiency is $d_i = 0$ and its competitor's deficiency is $d_j = 1$, because more consumers observe the true deficiency of the competitor which is higher than expected. In consequence, an increase in χ induces firms to invest more to avoid the loss in profits associated with their own high deficiencies and to increase the gain in profits associated with having the better product than the competitor. Thus, the higher the fraction of experts, the higher the investments.

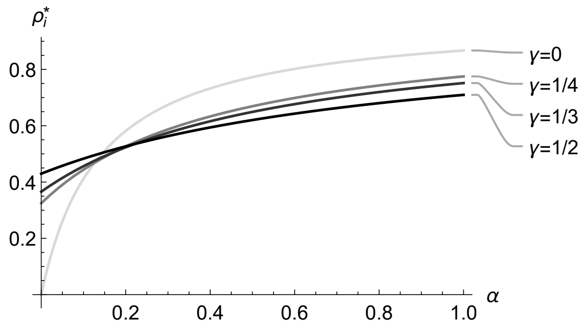
Figure 3.4 illustrates the effects of competition on investments in quality. Whether increasing competition induces firms to invest more or less depends to a large extent on the consumer side.[12] If there are only few aware consumers in the market, a monopolist invests less than a duopolist. With few aware consumers, most consumers do not take deficiencies into account. A monopolist thus has no incentives to invest to reduce his deficiency. In contrast, duopolists want to invest and disclose the existence of deficiencies to distinguish themselves from their competitor and attract more consumers. Consequently, if α is low, competitive pressure increases investments.

However, if α is high, competitive pressure reduces investments. If α is high, a monopolist has an incentive to invest because this allows him to charge all consumers higher prices. In contrast, duopolists cannot fully collect the additional willingness to pay that arises when firms have lower deficiencies, as they share the surplus with their competitor. Thus if α is high, a monopolist invests more than a duopolist.

The exact threshold where increasing competitive pressure becomes detrimental also depends on the fraction of experts in the market, because these experts take the true deficiency of the competitor into account: As $d_j = 1 > E[d]$, a firm that discloses benefits more if consumers observe the true deficiency of its silent competitor. In sum, increasing competition is not universally beneficial for investments in deficiency reductions and corresponding disclosure.

[11] See Appendix 3.8.5 for a detailed analysis of $(\partial\rho_i^*)/(\partial\chi)$.

[12] See Appendix 3.8.5 for a detailed analysis of $(\partial\rho_i^*)/(\partial\gamma)$. In general, there exists a $\bar{\alpha}$ such that $(\partial\rho_i^*)/(\partial\gamma) > 0 \Leftrightarrow \alpha < \bar{\alpha}$. For example, for $E[d] = 1/2$, $v = 5$, $c = 1$, and $\chi = \frac{1}{2}$, $0 \leq \bar{\alpha} \leq 1$. However, $0 \leq \bar{\alpha} \leq 1$ is not always fulfilled.



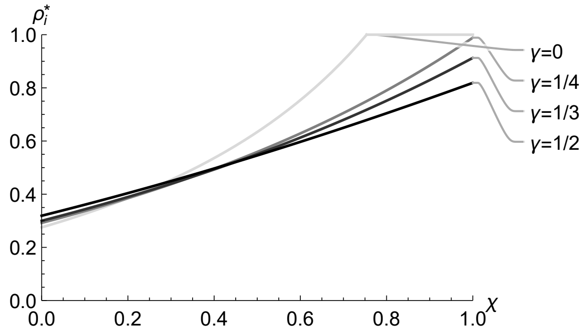


Figure 3.4: On the left side, investment in quality, ρ_i^*, as a function of the fraction of aware consumers α, with $E[d] = 1/2$, $v = 5$, $c = 1$, and $\chi = \frac{1}{2}$. On the right side, investment in quality, ρ_i^*, as a function of expert consumers χ, with $E[d] = 1/2$, $v = 5$, $c = 1$, and $\alpha = \frac{1}{4}$.

3.6.2 Policy Implications

In the long term, when firms can invest in quality, an increase in awareness, α, or in expertise, χ, puts pressure on firms to increase their investments in quality, see Figure 3.4. Consequently, an information campaign has two effects. First, information campaigns target the demand side and directly inform some consumers. Second, the increased awareness and expertise incentivizes firms to increase their investments in quality and subsequently disclose their deficiencies.

The effect of facilitated competition on investments, i.e., $(\partial\rho_i^*)/(\partial\gamma)$, depends on the fraction of aware consumers relative to the fraction of expert consumers in the market (see Section 3.6.1). Facilitating competition, i.e., an increase in γ, only increases investments if the fraction of aware consumers is sufficiently low.

In the long term, we focus on a probabilistic interpretation of deficiencies. Therefore, we focus here on minimum investments as policy intervention. The determination of the exact threshold of a minimum investment, $\underline{\rho}$, is an impediment which the market authority needs to consider. A market authority has to have perfect knowledge of the optimal investment decision by firms: Any minimum investment $\underline{\rho} < \rho_i^*$ will have no effect on the market transparency. In the extreme case, a market authority can implement $\underline{\rho} = 1$. This intervention ensures that all firms disclose in equilibrium. A less restrictive measure is to require a minimum investment, $\rho_i^* < \underline{\rho} < 1$. Yet, aware consumers may account for the minimum investment by adjusting their expectations, i.e., $E[d]_{new} < E[d]_{old}$. Then, according to Proposition 3, firms invest less to reduce the deficiency.[13] Consequently, such a minimum investment may be counterproductive.

[13] As $(\partial\rho_i^*)/(\partial E[d]) \geq 0$, if $E[d]$ decreases, the probability that firms disclose decreases.

3.7 Conclusion

We analyze the effects of frictions on the demand side, i.e., lack of awareness and lack of expertise, on the disclosure decision of the supply side. We show that, with unaware and amateur consumers in the market, market forces do not guarantee that firms disclose their deficiencies. In particular, we show that the existence of the equilibrium where both firms remain silent depends on the level of awareness and the level of expertise in the market. The levels of awareness and expertise in the market also determine the effects of competition on firms' incentives to disclose: If the fraction of aware consumers is sufficiently low relative to the fraction of expert consumers, more competition may lead to more disclosure. In contrast, if the fraction of aware consumers is sufficiently high relative to the fraction of expert consumers, more competition may lead to less disclosure.

We also investigate the effects of awareness, expertise, and competition on firms' investments in quality and subsequent disclosure of deficiencies. We show that increases in awareness and expertise lead to higher investments and subsequently more disclosure. In contrast, the effect of competition on investments depends on the awareness and expertise in the market. We find that if the fraction of aware consumers in the market is low relative to the fraction of expert consumers, a firm invests more the more intense the competition. But, a monopolist invests more than a firm that faces competition if the fraction of aware consumers is relatively high.

Taken together, these results leave room for policy interventions to increase market transparency. We discuss information campaigns, facilitating competition, and minimum standards. We show that neither information campaigns, facilitating competition, nor minimum standards universally induce firms to disclose in the short term, where firms are unable to invest to reduce deficiencies. Consequently, our results highlight that the market authority needs a good understanding of the market to implement an effective policy intervention.

In the long term, when firms can invest to reduce deficiencies, information campaigns lead to more investments and thus more disclosure. In contrast, facilitating competition and implementing minimum standards can be counterproductive. To provide good information campaigns, the market authority needs a good understanding of the possible deficiencies of goods. In cases where the market authority itself is unaware of a particular deficiency, as in the FFP2 masks case in the beginning of 2020, the market authority is unable to provide information campaigns. In contrast, facilitating competition is still possible. Although, facilitating competition does not always incentivize firms to disclose more, facilitating competition increases the incentives of firms to disclose in the short term in situations of extreme unawareness where the market authority is unaware as well.

3.8 Appendix

3.8.1 Proof Proposition 2

(i) Both firms disclosing with prices given in (3.6) is a subgame-perfect Nash equilibrium if

$$\pi_1^{DD} \geq \pi_1^{SD} \text{ and } \pi_2^{DD} \geq \pi_2^{DS} \;\Leftrightarrow\; d_i \leq E[d] \text{ for all } i \in \{1,2\}.$$

(ii) Only one firm disclosing with prices given in (3.4) and (3.5) is a subgame-perfect Nash equilibrium if

$$\pi_1^{DS} \geq \pi_1^{SS} \;\Leftrightarrow\; d_1(2-\gamma^2)(1-\alpha\chi) - d_2\gamma\chi(1-\alpha) \leq E[d](1-\chi)(\alpha(2-\gamma-\gamma^2)+\gamma)$$

and

$$\pi_2^{DS} \geq \pi_2^{DD} \;\Leftrightarrow\; d_2 \geq E[d]$$

or

$$\pi_1^{SD} \geq \pi_1^{DD} \;\Leftrightarrow\; d_1 \geq E[d]$$

and

$$\pi_2^{SD} \geq \pi_2^{SS} \;\Leftrightarrow\; d_2(2-\gamma^2)(1-\alpha\chi) - d_1\gamma\chi(1-\alpha) \leq E[d](1-\chi)(\alpha(2-\gamma-\gamma^2)+\gamma).$$

(iii) Both firms remaining silent with prices given in (3.3) is a subgame-perfect Nash equilibrium if

$$\pi_1^{SS} \geq \pi_1^{DS} \text{ and } \pi_2^{SS} \geq \pi_2^{SD}$$

$$\Leftrightarrow d_i(2-\gamma^2)(1-\alpha\chi) - d_j\gamma\chi(1-\alpha) \geq E[d](1-\chi)\big(\alpha(2-\gamma-\gamma^2)+\gamma\big) \text{ for all } i \in \{1,2\}.$$

3.8.2 Model with Bayesian Updating

Assume d_i is uniformly distributed on $[0, 1]$. We look for perfect Bayesian equilibria. Assume firm $j \in \{1, 2\}$ with $i \neq j$ discloses if $d_j < t$ and remains silent if $d_j > t$. Consumers who use Bayesian updating adjust their expectations according to the disclosure decision of the firms such that $E[d_i|Silent] = \frac{1+t}{2}$. The profit of firm i when it discloses is

$$\pi_i^D = \int_0^t \pi_i^{DD} dd_j + \int_t^1 \pi_i^{DS} dd_j.$$

The profit of firm i when it remains silent is

$$\pi_i^S = \int_0^t \pi_i^{SD} dd_j + \int_t^1 \pi_i^{SS} dd_j.$$

The threshold t is indirectly defined by

$$0 \leq t \leq 1 \text{ and } \pi_i^D(d_i = t) = \pi_i^S(d_i = t).$$

Figure 3.5 shows the disclosure threshold t as a function of α. Figure 3.6 shows the disclosure threshold t as a function of χ. Figure 3.7 shows the disclosure threshold t as a function of γ. As Figures 3.5, 3.6, and 3.7 show, including Bayesian updating in our model does not always lead to unraveling of deficiencies. Equilibria where both firms remain silent still exist. Therefore, the equilibrium where both firms remain silent in the main model does not hinge on the assumption about how consumers build expectations.

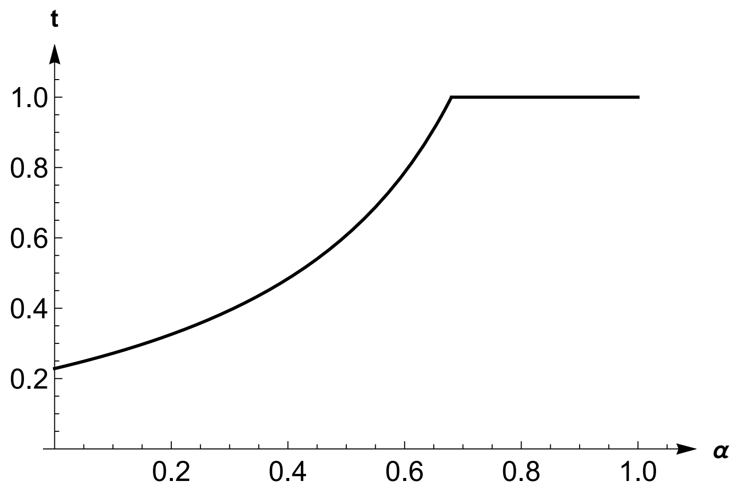


Figure 3.5: Disclosure threshold, t, as a function of α with $v = 5$, $\gamma = 0.5$, and $\chi = 0.5$.

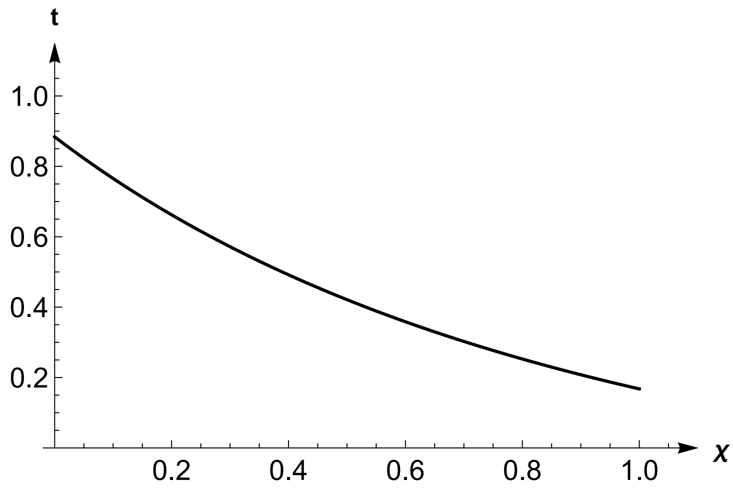


Figure 3.6: Disclosure threshold, t, as a function of χ with $v = 5$, $\gamma = 0.5$, and $\alpha = 1/3$.

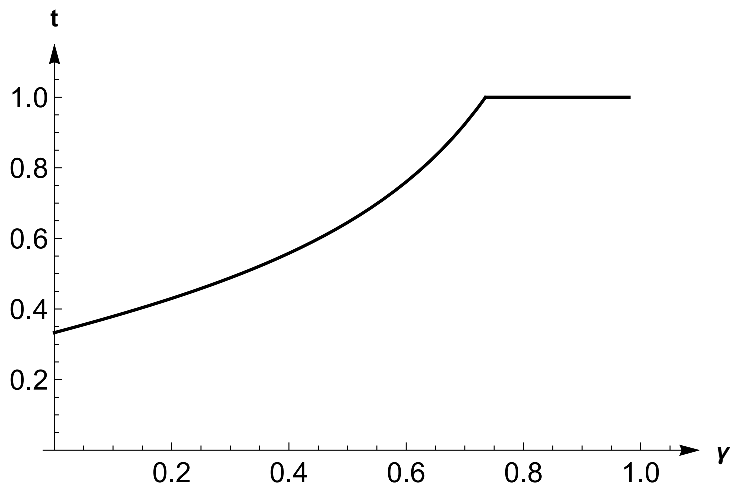


Figure 3.7: Disclosure threshold, t, as a function of γ with $v = 100$, $\alpha = 0.5$, and $\chi = 1/2$.

3.8.3 Proof Corollary 1 - 3

Let:

$$\tau \equiv d_1(2-\gamma^2)(1-\alpha\chi) - d_2\gamma\chi(1-\alpha) - E[d](1-\chi)\big(\alpha(2-\gamma-\gamma^2)+\gamma\big)$$

such that $\tau \geq 0$ is the condition for which Proposition 2 (iii) holds.

Corollary 1 is derived by analyzing the derivative of τ with respect to α:

$$\begin{aligned}
&\frac{\partial\tau}{\partial\alpha} > 0 \\
\Leftrightarrow\ & -d_1(2-\gamma^2)\chi + d_2\gamma\chi - E[d](1-\chi)(2-\gamma-\gamma^2) > 0 \\
\Leftrightarrow\ & \gamma > \gamma' \equiv -\frac{1}{2}\frac{d_2\chi + E[d](1-\chi)}{d_1\chi + E[d](1-\chi)} + \sqrt{2 + \Big(\frac{1}{2}\frac{d_2\chi + E[d](1-\chi)}{d_1\chi + E[d](1-\chi)}\Big)^2}
\end{aligned}$$

or

$$\gamma < -\frac{1}{2}\frac{d_2\chi + E[d](1-\chi)}{d_1\chi + E[d](1-\chi)} - \sqrt{2 + \Big(\frac{1}{2}\frac{d_2\chi + E[d](1-\chi)}{d_1\chi + E[d](1-\chi)}\Big)^2} < 0.$$

Thus, $\frac{\partial\tau}{\partial\alpha} > 0 \ \Leftrightarrow \gamma > \gamma'$. In contrast, $\frac{\partial\tau}{\partial\alpha} < 0 \Leftrightarrow \gamma < \gamma'$.

Corollary 2 is derived by analyzing the derivative of τ with respect to χ:

$$\begin{aligned}
&\frac{\partial\tau}{\partial\chi} > 0 \\
\Leftrightarrow\ & -d_1(2-\gamma^2)\alpha - d_2\gamma(1-\alpha) + E[d]\big(\alpha(2-\gamma-\gamma^2)+\gamma\big) > 0 \\
\Leftrightarrow\ & \alpha\big((2-\gamma^2)(E[d]-d_1) + \gamma(d_2 - E[d])\big) > \gamma(d_2 - E[d]).
\end{aligned} \tag{3.12}$$

If $d_1 < E[d] < d_2$, then $\frac{\partial\tau}{\partial\chi} > 0$ if and only if

$$\alpha > \alpha' \equiv \frac{\gamma(d_2 - E[d])}{(2-\gamma^2)(E[d]-d_1) + \gamma(d_2 - E[d])}$$

and $\frac{\partial\tau}{\partial\chi} < 0$ if and only if $\alpha < \alpha'$. In addition, we can rewrite (3.12) such that

$$\begin{aligned}
&\frac{\partial\tau}{\partial\chi} > 0 \\
\Leftrightarrow\ & \alpha(2-\gamma^2)(E[d]-d_1) > (1-\alpha)\gamma(d_2 - E[d]).
\end{aligned} \tag{3.13}$$

If $d_1 < d_2 < E[d]$, the left hand side of (3.13) is positive and the right hand side of (3.13) is negative such that $\frac{\partial\tau}{\partial\chi} > 0$ is always fulfilled. Furthermore,

$$\begin{aligned}
&\frac{\partial\tau}{\partial\chi} < 0 \\
\Leftrightarrow\ & \alpha(2-\gamma^2)(E[d]-d_1) < (1-\alpha)\gamma(d_2 - E[d]).
\end{aligned} \tag{3.14}$$

If $E[d] < d_1 < d_2$, the left hand side of (3.14) is negative and the right hand side of (3.14) is positive such that $\frac{\partial\tau}{\partial\chi} < 0$ is always fulfilled.

Corollary 3 is derived by analyzing the derivative of τ with respect to γ:

$$
\begin{aligned}
&\frac{\partial\tau}{\partial\gamma} > 0 \\
\Leftrightarrow\ & -2\gamma d_1(1-\alpha\chi) - \chi d_2(1-\alpha) + E[d](1-\chi)(\alpha(1+2\gamma)-1) > 0, \\
\Leftrightarrow\ & \alpha(2d_1\chi\gamma + d_2\chi + E[d](1-\chi)(1+2\gamma)) > 2d_1\gamma + d_2\chi + E[d](1-\chi) \\
\Leftrightarrow\ & \alpha > \alpha'' \equiv \frac{2d_1\gamma + d_2\chi + E[d](1-\chi)}{2d_1\chi\gamma + d_2\chi + E[d](1-\chi)(1+2\gamma)}.
\end{aligned}
$$

Note that $\alpha'' > 0$ is always fulfilled and

$$\alpha'' < 1 \Leftrightarrow d_1 < E[d].$$

Thus, if $d_1 < E[d]$, $\frac{\partial\tau}{\partial\gamma} > 0 \Leftrightarrow \alpha > \alpha''$ and $\frac{\partial\tau}{\partial\gamma} < 0 \Leftrightarrow \alpha < \alpha''$. If $d_1 > E[d]$, $\alpha < \alpha''$ is always fulfilled. Thus, if $d_1 > E[d]$, then $\frac{\partial\tau}{\partial\gamma} < 0$.

3.8.4 Proof Proposition 3

Let:

$$\bar{\gamma} \equiv 2 - \gamma - \gamma^2$$
$$\text{and } \bar{\chi} \equiv \chi + (1-\chi)E[d].$$

The profit of firm $i \in \{1,2\}$ (with $j \in \{1,2\}$ and $i \neq j$) is

$$\begin{aligned}
\Pi_i(\rho_i, \rho_j) =& \rho_i \rho_j \frac{1}{1-\gamma^2}\left(\frac{v\bar{\gamma}}{4-\gamma^2}\right)^2 + \rho_i(1-\rho_j)\frac{1}{1-\gamma^2}\left(\frac{v\bar{\gamma}+\gamma\bar{\chi}}{4-\gamma^2}\right)^2 \\
&+ (1-\rho_i)\rho_j \frac{1}{1-\gamma^2}\left(\frac{v\bar{\gamma}-(2-\gamma^2)\bar{\chi}}{4-\gamma^2}\right)^2 \\
&+ (1-\rho_i)(1-\rho_j)\frac{1}{1-\gamma^2}\left(\frac{v\bar{\gamma}-\alpha\bar{\gamma}\bar{\chi}}{4-\gamma^2}\right)^2 - c\rho_i^2.
\end{aligned}$$

Firm i chooses ρ_i to maximize its profit. As

$$\begin{aligned}
\frac{\partial \Pi_i(\rho_i,\rho_j)}{\partial \rho_i} =& \frac{1}{1-\gamma^2}\frac{1}{(4-\gamma^2)^2}\Big(\rho_j\,(v\bar{\gamma})^2 + (1-\rho_j)\,(v\bar{\gamma}+\gamma\bar{\chi})^2 \\
&- \rho_j\left(v\bar{\gamma}-(2-\gamma^2)\bar{\chi}\right)^2 - (1-\rho_j)\,(v\bar{\gamma}-\alpha\bar{\gamma}\bar{\chi})^2\Big) - 2c\rho_i,
\end{aligned}$$

the best reply is either

$$\begin{aligned}
\rho_i(\rho_j) =& \frac{\bar{\chi}}{2c(1-\gamma^2)(4-\gamma^2)^2}\Big(2v\bar{\gamma}(\gamma+\alpha\bar{\gamma}) + \bar{\chi}(\gamma^2-\alpha^2\bar{\gamma}^2) \\
&+ \rho_j\left(\bar{\gamma}^2(2v(1-\alpha)+\alpha^2\bar{\chi}) - \bar{\chi}(\gamma^2+(2-\gamma^2)^2)\right)\Big),
\end{aligned}$$

or, as $\rho_i \in [0,1]$, a boundary solution. Let

$$\bar{v} \equiv \frac{\bar{\chi}^2(2-\gamma^2)^2 + 2c(1-\gamma^2)(4-\gamma^2)^2}{2\bar{\gamma}\bar{\chi}(2-\gamma^2)}.$$

It is straightforward to show, that in equilibrium

$$\rho_i^* = \frac{2v\bar{\chi}\bar{\gamma}(\gamma+\alpha\bar{\gamma}) + \bar{\chi}^2(\gamma^2-\alpha^2\bar{\gamma}^2)}{2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}\bar{\gamma}^2(2v(1-\alpha)+\alpha^2\bar{\chi}) + \bar{\chi}^2(\gamma^2+(2-\gamma^2)^2)} \text{ if } v \leq \bar{v}$$

or

$$\rho_i^* = 1 \text{ if } v \geq \bar{v}.$$

3.8.5 The Effects of α, χ, and γ on the Investments

Let

$$\begin{aligned}
\bar{\chi} &\equiv \chi + (1-\chi)E[d],\\
\bar{\gamma} &\equiv 2-\gamma-\gamma^2,\\
\bar{v} &\equiv \frac{\bar{\chi}^2(2-\gamma^2)^2 + 2c(1-\gamma^2)(4-\gamma^2)^2}{2(2-\gamma-\gamma^2)\bar{\chi}(2-\gamma^2)}.
\end{aligned}$$

In the subgame-perfect Nash equilibrium, for all $i \in \{1,2\}$:

(i) $\rho_i^* = 1$ if $v \geq \bar{v}$

(ii) $\rho_i^* = \frac{2v\bar{\chi}\bar{\gamma}\left(\gamma+\alpha\bar{\gamma}\right)+\bar{\chi}^2\left(\gamma^2-\alpha^2\bar{\gamma}^2\right)}{2c(1-\gamma^2)(4-\gamma^2)^2-\bar{\chi}\bar{\gamma}^2\left(2v(1-\alpha)+\alpha^2\bar{\chi}\right)+\bar{\chi}^2\left(\gamma^2+(2-\gamma^2)^2\right)}$ if $v \leq \bar{v}$.

The effects of α on the investments

If $v \geq \bar{v}$:

$$\frac{\partial \rho_i^*}{\partial \alpha} = 0.$$

If $v < \bar{v}$:

$$\begin{aligned}
&\frac{\partial \rho_i^*}{\partial \alpha} > 0\\
\Leftrightarrow\ & \frac{2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}\bar{\gamma}^2\left(2v(1-\alpha)+\alpha^2\bar{\chi}\right)+\bar{\chi}^2\left(\gamma^2+(2-\gamma^2)^2\right)}{\left[2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}\bar{\gamma}^2\left(2v(1-\alpha)+\alpha^2\bar{\chi}\right)+\bar{\chi}^2\left(\gamma^2+(2-\gamma^2)^2\right)\right]^2}\\
&\times\left[2v\bar{\chi}\bar{\gamma}^2 - 2\alpha\bar{\chi}^2\bar{\gamma}^2\right]\\
&-\frac{\left[2v\bar{\chi}\bar{\gamma}(\gamma+\alpha\bar{\gamma})+\bar{\chi}^2\left(\gamma^2-\alpha^2\bar{\gamma}^2\right)\right]\left[2v\bar{\chi}\bar{\gamma}^2-2\alpha\bar{\chi}^2\bar{\gamma}^2\right]}{\left[2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}\bar{\gamma}^2\left(2v(1-\alpha)+\alpha^2\bar{\chi}\right)+\bar{\chi}^2\left(\gamma^2+(2-\gamma^2)^2\right)\right]^2} > 0\\
\Leftrightarrow\ & (v-\alpha\bar{\chi})\left(2c(1-\gamma^2)(4-\gamma^2)^2 - 2v\bar{\chi}\bar{\gamma}^2 + \bar{\chi}^2(2-\gamma^2)^2 - 2v\bar{\chi}\bar{\gamma}\gamma\right) > 0.
\end{aligned}$$

As $v > 2/(1-\gamma) > 1 > \alpha\bar{\chi}$ and

$$2c(1-\gamma^2)(4-\gamma^2)^2 - 2v\bar{\chi}\bar{\gamma}^2 + \bar{x}^2(2-\gamma^2)^2 - 2v\bar{\chi}\bar{\gamma}\gamma > 0 \Leftrightarrow v < \bar{v},$$

$(\partial\rho_i^*)/(\partial\alpha) > 0$.

The effects of χ on the investments

If $v \geq \bar{v}$:

$$\frac{\partial \rho_i^*}{\partial \chi} = 0.$$

If $v < \bar{v}$:

$$\begin{aligned}
&\frac{\partial \rho_i^*}{\partial \chi} > 0 \\
\Leftrightarrow\ & \frac{2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}\bar{\gamma}^2(2v(1-\alpha)+\alpha^2\bar{\chi}) + \bar{\chi}^2(\gamma^2+(2-\gamma^2)^2)}{\Big[2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}\bar{\gamma}^2(2v(1-\alpha)+\alpha^2\bar{\chi}) + \bar{\chi}^2(\gamma^2+(2-\gamma^2)^2)\Big]^2} \\
& \times \Big[2v\bar{\gamma} + 2\bar{\chi}(\gamma - \alpha\bar{\gamma})\Big](\gamma+\alpha\bar{\gamma})(1-E[d]) \\
-& \frac{\Big[2v\bar{\chi}\bar{\gamma} + \bar{\chi}^2(\gamma-\alpha\bar{\gamma})\Big](\gamma+\alpha\bar{\gamma})(1-E[d])}{\Big[2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}\bar{\gamma}^2(2v(1-\alpha)+\alpha^2\bar{\chi}) + \bar{\chi}^2(\gamma^2+(2-\gamma^2)^2)\Big]^2} \\
& \times \Big[-2v\bar{\gamma}^2(1-\alpha) - 2\alpha^2\bar{\chi}\bar{\gamma}^2 + 2\bar{\chi}(\gamma^2+(2-\gamma^2)^2)\Big] > 0 \\
\Leftrightarrow\ & 2v\bar{\gamma}\big[2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}^2(2-\gamma^2)(2-\gamma^2+\gamma-\alpha\bar{\gamma})\big] \\
& > 4c\bar{\chi}(1-\gamma^2)(4-\gamma^2)^2(\alpha\bar{\gamma}-\gamma).
\end{aligned} \tag{3.15}$$

The left hand side of (3.15) is positive if

$$c > \frac{\bar{\chi}^2(2-\gamma^2)(2-\gamma^2+\gamma-\alpha\bar{\gamma})}{2(1-\gamma^2)(4-\gamma^2)^2} \equiv \bar{c}.$$

But $c > \bar{c}$ is always fulfilled, because the interior solution of ρ_i^* only exists if

$$\bar{v} > v > \frac{2}{1-\gamma}$$

and for this range of v to exist

$$\bar{v} > \frac{2}{1-\gamma} \Leftrightarrow c > \frac{4(2-\gamma^2)(2+\gamma)\bar{\chi} - \bar{\chi}^2(2-\gamma^2)^2}{2(1-\gamma^2)(4-\gamma^2)^2} > \bar{c}.$$

Consequently, the left hand side of (3.15) is always positive.

In contrast, the right hand side of (3.15) is positive if $\alpha\bar{\gamma} \geq \gamma$ and is negative if $\alpha\bar{\gamma} < \gamma$. Consequently, if $\alpha\bar{\gamma} < \gamma$, the right hand side is negative, which means $(\partial\rho_i^*)/(\partial\chi) > 0$.

If $\alpha\bar{\gamma} \geq \gamma$,

$$\begin{aligned}
&\frac{\partial \rho_i^*}{\partial \chi} > 0 \\
\Leftrightarrow\ & v > \frac{4c\bar{\chi}(1-\gamma^2)(4-\gamma^2)^2(\alpha\bar{\gamma}-\gamma)}{2\bar{\gamma}\big[2c(1-\gamma^2)(4-\gamma^2)^2 - \bar{\chi}^2(2-\gamma^2)(2-\gamma^2+\gamma-\alpha\bar{\gamma})\big]}.
\end{aligned}$$

Yet, as $v > 2/(1-\gamma)$ and

$$\bar{v} > \frac{2}{1-\gamma} \Leftrightarrow c > \frac{4(2-\gamma^2)(2+\gamma)\bar{\chi} - \bar{\chi}^2(2-\gamma^2)^2}{2(1-\gamma^2)(4-\gamma^2)^2},$$

this is always fulfilled. In sum, if $v < \bar{v}$, $(\partial\rho_i^*)/(\partial\chi) > 0$.

The effects of γ on the investments

Let

$$\begin{aligned} m \equiv & 2\bar{\chi}^2\bar{\gamma}\big(2c\bar{\gamma}(2-\gamma)(2+\gamma)^2(1-\gamma+\gamma^2) - v\bar{\chi}\bar{\gamma}(2+\gamma^2) + \bar{\chi}^2(4-\gamma^4)\big) \\ n \equiv & 4c\bar{\chi}\big(v\bar{\gamma}^2(2-\gamma)(4+2\gamma+4\gamma^2+3\gamma^3) + \bar{\chi}\gamma(16-9\gamma^4+2\gamma^6)\big) \\ & -2(2+\gamma^2)\bar{\chi}^2\big(v\bar{\gamma}^2 + \bar{\chi}\gamma(2-\gamma^2)\big)(2v-\bar{\chi}). \end{aligned}$$

If $v \geq \bar{v}$:

$$\frac{\partial\rho_i^*}{\partial\gamma} = 0.$$

If $v < \bar{v}$:

$$\begin{aligned} \frac{\partial\rho_i^*}{\partial\gamma} > 0 & \Leftrightarrow \alpha^2 m - 2\alpha\frac{v}{\bar{\chi}}m + n > 0 \\ & \Leftrightarrow (\alpha - \frac{v}{\bar{\chi}})^2 > \underbrace{\frac{v^2}{\bar{\chi}^2} - \frac{n}{m}}_{>0} \\ & \Leftrightarrow \alpha > \alpha_1 \equiv \frac{v}{\bar{\chi}} + \sqrt{\frac{v^2}{\bar{\chi}^2} - \frac{n}{m}} \\ & \quad \text{or} \\ & \quad \alpha < \alpha_2 \equiv \frac{v}{\bar{\chi}} - \sqrt{\frac{v^2}{\bar{\chi}^2} - \frac{n}{m}}. \end{aligned}$$

As $v > 2/(1-\gamma) > 1 > \bar{\chi}$ and $\sqrt{v^2/(\bar{\chi}^2) - n/m} > 0$, $\alpha_1 > 1$. Therefore, $(\partial\rho_i^*)/(\partial\gamma) > 0$ if and only if $\alpha < \alpha_2$ and, in contrast, $(\partial\rho_i^*)/(\partial\gamma) < 0$ if and only if $\alpha > \alpha_2$. Note that $0 \leq \alpha_2 \leq 1$ is not always fulfilled.

Chapter 4

Secondary Markets Revisited

Dominik Bruckner

The existing literature on secondary markets for used goods assumes that a monopolist in the primary market may benefit from and desire a secondary market. I extend the existing literature by analyzing the organizational structure of the secondary market. In particular, I propose a model in which an intermediary such as a platform organizes the secondary market. I put forward two central roles of a secondary market platform: to enable consumers of horizontally differentiated primary market firms to trade used products, and to make consumers aware of secondary market opportunities. The presence of an intermediary alters the well-known trade-off between the cannibalization and the valuation effect. The analysis explains the development of secondary markets in recent years.

Keywords: Platform, Secondary Markets, Used Goods Market, Attention.
JEL Codes: L22, L81.

4.1 Introduction

Secondary markets are today primarily organized by platforms. In addition, consumers in various industries, from electronics to fashion, are shifting their focus from the primary to the secondary market, leading to significant secondary market growth.[1] The emergence of platforms as secondary market organizers leads to a new trade-off for a monopolist running the primary market. Today, a monopolist may prefer a closed secondary market or the closure of the secondary market, because otherwise the secondary market will cannibalize the profits of the primary market.

This article analyzes the role of secondary markets and their renaissance in industrial organizations. The main body of research, starting with Anderson & Ginsburgh (1994) and Hendel & Lizzeri (1999), has focused on the trade-off between the cannibalization effect and the valuation effect. The authors conclude, that a monopolist may profit by the existence of secondary markets and therefore desires a secondary market. I reassess this trade-off by introducing more realistic assumptions regarding the secondary market. Both seminal papers (Anderson & Ginsburgh 1994, Hendel & Lizzeri 1999) do not specify the structure or the functioning of the secondary market. A secondary market is different from traditional markets and products because for a secondary market to exist, there must be matched consumers willing to resell and buy used products. Today, most secondary markets are therefore operated by platforms, such as *Vinted* for fashion or *Rebuy* for electronics.

I extend the model of Anderson & Ginsburgh (1994) to include a third player, a platform that organizes the secondary market. I argue that a platform affects the secondary market in three different ways: First, the platform reduces transaction costs for consumers relative to the the natural transaction costs[2]. Second, the platform connects firms in separate primary markets through the secondary market. Third, the platform makes consumers aware of secondary market opportunities. These last two platform features fundamentally change the monopolist's benefit of secondary markets. Connecting multiple primary market firms via the platform will change the secondary market price mechanism. The connection of previously unaware consumers will affect the primary market price mechanism. Thus, the key features of a platform reduce the valuation effect and lead to a more pronounced cannibalization effect. As a result, a monopolist may establish its own closed secondary market.

In the following, I start with a classic flea market example, borrowed from Anderson & Ginsburgh (1994), which involves significant costs for both sellers and buyers of used goods. I will then introduce a platform that organizes the secondary market and reduces transaction costs by matching buyers and sellers of used products. Subsequently, I will discuss and analyze the two connecting features of a platform. First, I show that the valuation effect vanishes once a platform connects two monopolists through the secondary market. Then, primary market firms can only extract surplus from buyers who are willing to pay for *freshness*. Consequently, primary market firms prefer closed secondary markets or no secondary markets at all. Second, I show that

[1] Business analysts predict that the secondary market growth will exceed the primary market growth in the next years. For example, for the United States' secondary fashion market, experts predict a threefold increase in volume from 2019 to 2029, see Thredup (2022).

[2] I define *natural* transaction costs as the costs of searching and waiting that consumers incur without using any help. For example, these may be the time of browsing used products in a second-hand shop or a flea market.

a monopolist may prefer flea markets or no secondary markets if a platform connects unaware consumers to the secondary market. Dependent on the industry characteristics, a monopolist prefers to inform consumers about the valuation effect only if consumers are sufficiently aware in the first place.

Various industries already put extensive focus on the secondary market.[3] In some cases the monopolist herself organizes and owns the secondary market. An example of a monopolist that also provides a secondary market is the fashion company *Zara*. Zara allows consumers to resell and to buy their clothes previously purchased on the primary market. Similarly, there are platforms that offer consumers access to both the primary and the secondary market. To give an example: the fashion platform *Zalando* provides access to the regular primary market and allows consumers to resell as well as to buy the used clothes. Importantly, both examples show that firms aim to *close* their secondary market, i.e., consumers are only allowed to resell and buy used products, previously bought on the same primary market. Finally, there are platforms that operate independently of the primary market. Two examples of major second hand platforms that operate only on the secondary market are *Vinted* and *Rebuy*. Such platforms advertise the benefits of buying and selling on the secondary markets to consumers. Thus, they make consumers aware of secondary market opportunities.

The remainder of the article is structured as follows. Section 4.2 reviews the related literature. Section 4.3 introduces the baseline model. Subsequently, I extend the baseline model to include the central features of a platform. In Section 4.4, I highlight the role of different industry characteristics and discuss possible extensions. Section 4.5 concludes.

4.2 Related Literature

This article primarily relates to the industrial organization literature of secondary markets. In addition, this work borrows from the literature of platform economics as well as the economic literature of inattention.

The recent theoretical literature on secondary markets is surprisingly scarce.[4] Much of the literature since the mid-1990s emphasises the trade-off a monopolist faces when operating on the primary market and indirectly providing used products to the secondary market (see Anderson & Ginsburgh 1994, Hendel & Lizzeri 1999). Waldman (2003) gives a broad overview of the literature and summarizes the reasons for secondary markets as follows: *As units age and fall in quality, the units are traded from high-valuation to low-valuation consumers.* Johnson (2011) discusses secondary markets as a consequence of a change in preferences. He argues that secondary market trade does not take place because of depreciation in quality but because of new styles or changes in fashion.[5]

The majority of the theoretical literature follows the explanation of Waldman (2003). For example, Kogan (2011) and Ghose et al. (2005) discuss secondary markets but focus on the relationship between a retailer and a supplier, i.e., a supply chain. Schiraldi & Nava (2012)

[3] See for example Schulz (2023).

[4] There exists the huge strand of literature concerning asymmetric information in secondary markets starting with the seminal work of Akerlof (1970). However, in the following, informational asymmetries do not play a role.

[5] Blonigen et al. (2017) argue similarly, but focus on the implications of redesign decisions of firms.

discuss the special case of semi-durable products in secondary markets and focus on firm's decision to collude in the primary market. Furthermore, Oraiopoulos et al. (2012) highlight the special case of original equipment manufacturers in the IT industry. In this specific industry, original equipment manufacturers can take actions to shut down the secondary market, for example by introducing a re-licensing fee for used products. In general, this literature highlights the central trade-off between the valuation and cannibalization effect. Similarly, I evaluate this trade-off with a platform organizing the secondary market and discuss cases where a monopolist prefers to close the secondary market.

Most recently, the research focus shifted to more policy relevant topics. To give one example, Jin et al. (2022) focus on the right to repair. They model their economy, with a primary and secondary market, where the product might stop working. Consumers then decide on whether to repair or buy anew. Repairing options have a positive impact on the valuation effect and alter the trade-off a monopolist faces.

The two seminal papers of Anderson & Ginsburgh (1994) and Hendel & Lizzeri (1999) analyze the benefits of secondary markets for a monopolist. The central argument, which also applies in the following, is that a monopolist's primary market demand increases through the secondary market, because *consumers anticipate a secondary resale value* (see Anderson & Ginsburgh 1994). This is called the *valuation effect*. Conversely, the secondary market can also reduce the primary market demand as more and more consumers buy used rather than new. This is called the *cannibalization effect*. Both Hendel & Lizzeri (1999) and Anderson & Ginsburgh (1994) discuss a monopolist's preference for transaction costs in the secondary market. Transaction costs drive a wedge between buyer and seller prices in the secondary market and make the secondary market less appealing to consumers. In addition, both articles put an emphasis on planned obsolescence and optimal product durability. Hendel & Lizzeri (1999) extend their analysis by discussing leasing opportunities (see also Gavazza (2011) for the empirical argument). As an alternative to traditional secondary markets, leasing reduces transaction costs and fosters the valuation effect.

In the following, I build mainly on the seminal work of Anderson & Ginsburgh (1994). I adapt their setting to today's economy of secondary markets. In particular, I discuss the role of the valuation and cannibalization effect if a platform is organizing the secondary market. First, I argue that platforms today mainly organize secondary markets and thereby reduce the transaction costs present in secondary markets. Congruent to Anderson & Ginsburgh (1994) and Hendel & Lizzeri (1999), a monopolist may welcome a platform that organizes the secondary market if the platform merely reduces transaction costs. Second, similar to the research of Ghose et al. (2005), I propose one central function of a platform as connecting firms. This allows consumers to buy used products from various firms on the secondary market.[6] Third, I analyze the role of inattention towards secondary markets. The greater part of the literature ignores that some consumers may not take the secondary market into consideration. Yet, previous psychological and economic research has established that consumers may not consider all available options i.e., consumers may act myopically.[7] Both Hendel & Lizzeri (1999) and Anderson & Ginsburgh

[6] In other words, the platform allows consumers to take into account additional products on the secondary market, which they do not necessarily took into account before.

[7] For an overview of the economic literature on inattention see Gabaix (2019). For example Lacetera et al.

(1994) assume that the consumer side is perfectly aware of secondary markets: All buyers are aware of used products and all sellers take into account to sell on the secondary market. In contrast, I vary the consumer side. In particular, I extend the model in such a way that it accounts for different consumer types. I show that a monopolist is only interested in secondary markets, if the total consumer side is sufficiently attentive in the first place and if the industry characteristics are sufficiently balanced. [8]

Miao (2010) is one of the few papers which implement myopic consumer behavior in a model with a duopoly on the primary market and a subsequent aftermarket. In contrast to the present paper, Miao (2010) assumes that aftermarket sales are necessary for the long-run use of primary market goods. He shows that competition on the primary market does not prevent firms to earn a positive profit if they can strategically commit to incompatibility on the aftermarket. Then, firms' profit rests on the the existence of myopic consumers. The modelling approach of Miao (2010) relates to my model in the sense of myopic consumer behaviour. He proposes that consumer overlook long-run costs and the existence of significant aftermarket markups. Similarly, I argue that consumers overlook the existence and consequently the benefits of the secondary market, i.e., buying as well as selling benefits. Whereas, Miao (2010) analyzes a special case of secondary markets, i.e., aftermarkets, I focus on myopic consumer behaviour in a general secondary market setting.

A number of studies have empirically examined secondary markets. The most common example and empirical research object is that of the secondary car market, see for example Esteban & Shum (2007), Chen et al. (2013), Gavazza (2011), Gavazza et al. (2014), and Gillingham et al. (2022). One central feature of most studies is the importance of transaction costs in the secondary market. Interestingly, Chen et al. (2013) find a negative effect on primary market profits once the secondary market becomes frictionless. Other authors focus on special product characteristics such as information goods, e.g. Ghose et al. (2005), or event tickets, e.g. Lewis et al. (2019). Ishihara & Ching (2019) analyze the video game industry and argue that the closing of secondary market retailers may result in a 7.3 per cent increase in primary market profits. In the following, I account for the importance of transaction costs and argue that secondary market platforms fundamentally alter secondary market benefits for primary market firms. The recent empirical evidence shows that with the emergence of platforms organizing secondary markets, primary market firms increasingly prefer closed secondary markets. Instead of focusing on one specific industry I will illustrate the results of my model with a neutral example. At the end of the article, I will discuss further implications of varying industry characteristics.

(2012) find empirical evidence regarding limited attention in the used car market.

[8] I define industry characteristics as the relation between freshness utility and base utility, which may differ across industries.

4.3 Model

Besides platforms, flea markets are one of the most common form of secondary markets (see for example Wilts & Fecke 2020). The common denominator between a platform and a flea market is that sellers and buyers of used products seek to find a match. However, a traditional flea market usually involves significantly higher transaction costs for both buyers and sellers. In the following, I first present the baseline case of a flea market. Second, I argue that platforms organize secondary markets in order to eliminate some of the transaction costs present in flea markets. In contrast to flea markets, platforms ensure or increase the likelihood of a match between a seller and a buyer. Having established the platform structure of a secondary market, I will then show how product competition in the secondary market as well as increased awareness of the secondary market, induced by platforms, changes the monopolist's preference regarding the secondary market.

4.3.1 Flea Market

The situation of a flea market style secondary market is best captured by an extension of the baseline model of Anderson & Ginsburgh (1994). In the baseline model, the secondary market is assumed to run independently of a decisive player. Any owner of a new product can sell, and any consumer can choose to buy on the secondary market. However, I also assume that a flea market is defined by:

- Sellers having to wait to find a buyer, i.e., waiting costs ω^*.[9]
- Buyers searching for sellers, i.e., search costs τ^*.

For now these transaction costs, τ^* and ω^*, are exogenous parameters. Throughout this section, I focus on instances where a secondary market exists. This means, that τ^* and ω^* are in such a range that some consumers find it worthwhile to buy new as well as sell and some consumers visit the flea market to buy used.[10]

Similar to Anderson & Ginsburgh (1994), I assume that any consumer who buys a product gains a base utility v. In addition, consumers receive a freshness utility k, when they purchase a new product. Consumers buy a maximum of one product per period (used or new). A new product becomes used after one period and perishes after the second period. Consumers differ in their willingness to pay for freshness denoted by θ. I assume that θ is uniformly distributed on the interval $[0, 1]$. The higher θ, the higher the willingness to pay. Let p_n denote the price for a new product and p_s the price for a used product. The consumers' utility is then summarized by:

$$\begin{aligned}
U_n &= 2(\theta(v+k) - p_n + p_s - \omega^*), \\
U_k &= \theta(2v+k) - p_n, \\
U_s &= 2(\theta v - p_s - \tau^*), \\
U_0 &= 0.
\end{aligned}$$

[9]This can also be interpreted as the probability of not finding a buyer.

[10]A secondary market exists as long as $\frac{k(2v+k)}{16v+6k} > \omega, \tau$.

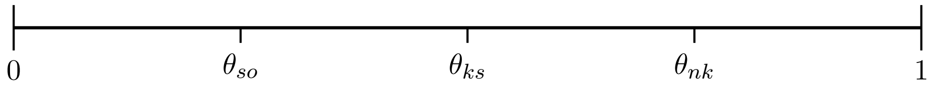


Figure 4.1: Consumer Groups.

Consumers can either buy new for two periods and sell their used products via the flea market, gaining utility U_n, buy new and keep their used product for the second period, gaining utility U_k, buy used for two periods, gaining utility U_s, or, stay inactive, gaining utility U_o. Naturally, the consumers' utility in the case of keeping a new product for the second period remains unaffected by any transaction cost.[11]

Dependent on the willingness to pay, θ, the three thresholds for the consumer groups are:

$$\theta_{nk} = \frac{p_n - 2p_s + 2\omega^*}{k}, \quad \theta_{ks} = \frac{p_n - 2p_s - 2\tau^*}{k}, \quad \theta_{so} = \frac{p_s + \tau^*}{v},$$

where Figure 4.1 depicts the relationship of all thresholds. It is straight forward to see that the consumer group buying new every period, $1 - \theta_{nk}$, decreases if sellers face higher waiting cost ω on the secondary market. In other words, the threshold where consumers begin buying new for both periods, θ_{nk}, moves to the right in Figure 4.1. The amount of consumers keeping a new product, $\theta_{nk} - \theta_{ks}$, increases with both waiting and search cost. Thus, the threshold where consumers start buying new for one period and keep, θ_{ks}, extends further to the left in Figure 4.1. The amount of consumer buying only used products, $\theta_{ks} - \theta_{so}$, decreases if search cost increase. Vice versa, the inactive consumer group increases if buyers face higher search cost τ^* on the secondary market. Put differently, the threshold where consumers become active on the secondary market, θ_{so}, advances to the right in Figure 4.1.

The monopolist chooses a primary market price to maximize its profit, $\pi_M = D(p_n) \times p_n$. For simplicity, I assume that the monopolist has zero cost of production. The monopolist's demand on the primary market consists of all consumers who buy new for two periods and consumers who only buy new for one period and keep for the second period:

$$\begin{aligned} D(p_n) &= 2(1 - \theta_{nk}) + (\theta_{nk} - \theta_{ks}) \\ &= 2 - \frac{p_n - 2p_s + 2\omega^*}{k} - \frac{p_n - 2p_s - 2\tau^*}{k}. \end{aligned}$$

Figure 4.2 summarizes the timing of events. First, Nature draws waiting and search costs for consumers. Second, a monopolist decides for the next two periods on prices in the primary market. Third, consumers decide whether to buy new on the primary market, keep their previously bought product, buy used on the flea (secondary) market or stay inactive. I solve for equilibrium prices and profit via backward induction.

[11] I follow the interpretation of Anderson & Ginsburgh (1994) regarding the two period set up: One can interpret consumers as living for ever. Alternatively, one can interpret the model as an overlapping generation framework, where each period a new generation enters and an old generation of equal size leaves the market.

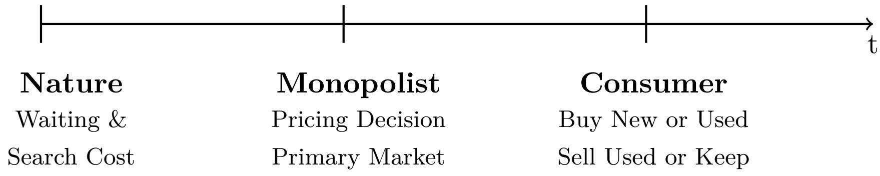


Figure 4.2: Flea Market - Timeline.

Flea Market Results

The equilibrium secondary market price is determined by the supply of all consumers who buy new every period on the primary market, $1-\theta_{nk}$, balancing the demand of the secondary market, $\theta_{ks}-\theta_{so}$:

$$1-\theta_{nk}=\theta_{ks}-\theta_{so}$$
$$1-\frac{p_n-2p_s+2\omega^*}{k}=\frac{p_n-2p_s-2\tau^*}{k}-\frac{p_s+\tau^*}{v},$$

leading to the secondary market price:

$$p_s=\frac{2vp_n-k(\tau^*+v)+2v(\omega^*-\tau^*)}{4v+k}. \tag{4.1}$$

The monopolist chooses a primary market price to solve the first order condition:

$$\frac{\partial\pi_M}{\partial p_n}=0.$$

Importantly, the monopolist accounts for the valuation and cannibalization effect implied by the secondary market, i.e., the monopolist accounts for Equation (4.1) in her demand function:

$$D(p_n)=2-\frac{2}{k}(p_n+\omega^*-\tau^*-\frac{4vp_n-2k(\tau^*+v)+4v(\omega^*-\tau^*)}{4v+k}).$$

This leads to the equilibrium primary market price:

$$p_n^*=\frac{k+2v-\tau^*-\omega^*}{2}, \tag{4.2}$$

and a monopolist profit:

$$\pi_M^*=\frac{(\tau^*+\omega^*-k-2v)^2}{2(k+4v)}. \tag{4.3}$$

According to Equation 4.1, the secondary market price decreases with search costs and increases with waiting costs. In other words, either buyers have to bear the burden of sellers to wait, or sellers have to bear the burden of buyers to search. When search and waiting costs are equally high, only search cost influence the secondary market price. The reason is that search costs directly affect the threshold of three consumer groups (keeping, buying used and staying inactive) whereas waiting cost only affect the threshold of consumers who buy always new or buy new and keep.

Search costs hinder some consumers to visit the secondary market and thus reduce the secondary market demand. Similarly, as sellers expect to get reimbursed for waiting for buyers, the secondary market price increases, resulting in a reduced secondary market demand. Consequently, both search and waiting costs make it less *valuable* to buy a new product and resell it on the secondary market. More and more consumers will choose to buy new in the first period and keep for the second period, instead of buying new both periods and sell or buying used on the secondary market.[12]

In contrast to the secondary market price, the primary market price is independent of the consumer group who bears the transaction cost, see Equation 4.2. Both waiting and search cost (partly) reduce the primary market price with equal weight. The intuition is that the monopolist lowers the primary market price to compensate for *any* frictions occurring in the secondary market. A monopolist's profit is thus negatively impacted by both types of transaction costs, see Equation 4.3.[13] Therefore, the monopolist prefers consumers to have perfect access to the secondary market, i.e., $\omega = \tau = 0$.

Numerical Example

To give a numerical example and comparison, which I will also come back to in the subsequent sections, consider a monopolist with product characteristics $v = k = 10$.

If no secondary market exists, i.e., for example because search and waiting costs are very high, $\omega, \tau > \frac{k(v+k))}{16v+6k}$, the primary market price and the monopolist's profit are:

$$p_n = 7.5,$$
$$\pi_M = 7.5.$$

A quarter of consumers buy new every period, while half of all consumers buy a new product once and keep it for the second period. The remaining consumers, a quarter, are not willing to enter the market.

When consumers have the possibility to visit a flea market where they face natural search and waiting costs of $\tau^* = \omega^* = 1$, the numerical equilibrium outcome on the flea market is characterized by:

$$p_n = 14,$$
$$p_s = 3.4,$$
$$\pi_M = 7.84.$$

Now, eight per cent of consumers buy new every period and resell their used product via the secondary market, i.e., $1 - \theta_{nk} = 0.08$. Forty per cent of consumers buy new in the first period and keep for the second period, i.e., $\theta_{nk} - \theta_{so} = 0.4$. Most consumers stay inactive, i.e., $\theta_{so} = 0.44$. The remaining consumers use the secondary market and buy used for both periods,

[12] θ_{ks} decreases to the left and θ_{nk} increases to the right of Figure 4.1, leading to a greater fraction of $\theta_{nk} - \theta_{ks}$.

[13] Since base and freshness utility are by assumption $v, k > 0$, transaction costs always decrease the monopolist's profit.

i.e., $\theta_{ks} - \theta_{so} = 0.08$.

A comparison of the monopolist's profit clarifies that a monopolist prefers a secondary market. The profit increases because the secondary market allows for the valuation effect to take place, i.e., consumers who buy new every period, can sell their used items and finance their new purchase in the next period. The secondary market ensures that new products have a resell *value*. However, fewer consumers purchase any product. The increased primary market price and the transaction costs lead to a 76 per cent increase in the number of inactive consumers.

In today's economy we see secondary markets for almost every type of durable product. Thanks to intermediaries such as platforms or retailers a profound reduction in waiting and search costs allows for a wide range of secondary markets. However, a platform organizing the secondary market changes the basic model and the behaviour of the monopolist. In the next section, I will extend the model by introducing a strategic third player, the platform, and show that the key features of a platform can change the monopolist's behavior as well as her preference for consumers who have full access to secondary markets.

4.3.2 Independent Platforms and Retailers

When a platform organizes the secondary market, the model is modified as follows:

- Sellers and/or buyers may pay a transaction fee in order to enter the platform. Once sellers and buyers enter, they do not face any search or waiting cost.[14]

Consequently, a third player the platform I is integrated into the model. The platform maximizes its profit by implementing a transaction fee τ for buyers and ω for sellers of used products, accounting for the secondary market trading volume implemented by the respective transaction fee:

$$\pi_I = 2(1 - \theta_{nk})\omega + 2(\theta_{ks} - \theta_{so})\tau. \tag{4.4}$$

In comparison, when a retailer organizes the secondary market, the retailer buys all used products from the product owners and sells them to consumers who buy used. A retailer's profit equals the secondary market price asked from consumers, p_s^a, less the bid price paid to owners of new products, p_s^b:

$$\pi_I = p_s^a \times D(p_s^a) - p_s^b \times S(p_s^b).$$

In contrast to a platform, a retailer herself decides on secondary market prices.[15] In the present framework, where consumer types are assumed to be uniformly distributed, and every seller only sells one product previously bought for the same price p_n, the intermediary type, i.e., platform or retailer, does not matter (see Belleflamme & Peitz 2015, chap. 22). Therefore, in the following I focus on the platform structure of the secondary market and briefly discuss the intermediaries specific type in later sections.

Figure 4.3 illustrates the new timeline of the model with an independent platform organizing the secondary market. First, the platform decides on secondary market transaction fees for sellers and buyers. Second, the monopolist decides about the primary market price. Lastly, consumers decide whether to enter the platform dependent on the platform's transaction fee. Naturally, consumers only use the platform if natural search and waiting costs are higher compared to the platforms transaction fee, i.e., $\tau < \tau^*$ and $\omega < \omega^*$.

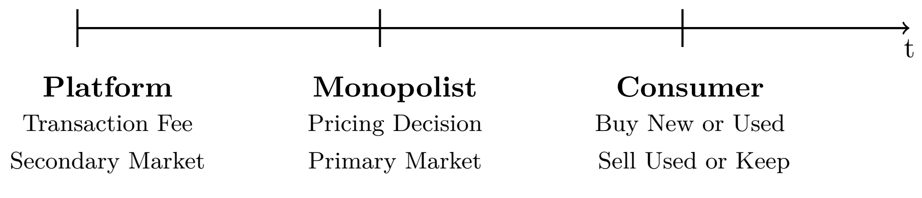


Figure 4.3: Independent Platform - Timeline.

[14] This can also be interpreted as a platform's transaction fee to ensure (or increase) the likelihood of a buyer-seller match.

[15] In other words, on a platform the risk of a match is still borne by the individual consumer, whereas the retailer herself faces the risk of finding a buyer.

Platform Results

Using backward induction, it is straightforward to see that the results from the previous flea market case remain similar: Only the transaction costs considered by the consumers and the monopolist differ. The secondary market price mechanism, i.e., Equation 4.1, and the price setting behaviour of the monopolist, i.e., Equation 4.2, still hold. In the first stage of the game, the platform decides on its transaction fees. The platform faces a trade-off between maximizing the secondary market volume, $D(p_s)$, and charging higher transaction fees, ω and τ. An increase (decrease) in transaction fees implies a decrease (increase) in the trading volume.

If natural waiting and search costs are equally high and consumer types are uniformly distributed, the platform will charge sellers and buyers the same transaction fee in the secondary market (see Appendix 4.6.1 for the proof). Intuitively, for a platform to match every buyer to a seller it must still hold that supply equals demand on the secondary market. In other words, sellers as well as buyers are equally beneficial for a platform. Therefore, Equation 4.4 simplifies to:

$$\pi_I = 2\big((1-\theta_{nk}) + (\theta_{ks} - \theta_{so})\big) \times T,$$

where T is the transaction fee asked from sellers as well as buyers entering the secondary market platform.

The platform accounts for the primary market price, i.e., Equation 4.2, as well as the secondary market price, i.e, Equation 4.1, and maximizes its profit according to:

$$\max_T 2\big(1 - \frac{p_n - 2p_s + 2T}{k} + \frac{p_n - 2p_s - 2T}{k} - \frac{p_s + T}{v}\big) \times T.$$

Solving the first order condition $\frac{\partial \pi_I}{\partial T} = 0$ yields the optimal transaction fee:

$$T^* = \frac{k(k+2v)}{4(3k+8v)}. \tag{4.5}$$

The resulting equilibrium primary and secondary market prices are:

$$p_n^* = \frac{(k+2v)(5k+16v)}{4(3k+8v)},$$
$$p_s^* = \frac{20kv^2 + 64v^3 - k^3 - 4k^2v}{4(k+4v)(3k+8v)}.$$

With a platform operating the secondary market, the respective profits in equilibrium are:

$$\pi_M^* = \frac{(k+2v)^2(5k+16v)^2}{8(k+4v)(3k+8v)^2},$$
$$\pi_I^* = \frac{k(k+2v)^2}{4(k+4v)(3k+8v)}.$$

A platform will ensure a secondary market for all industry characteristics since $T^* < \frac{k(v+k)}{16v+6k}$. In other words, if natural transaction costs allow for any secondary market, a platform will always ask for transaction fees such that consumers are willing to enter the platform. The transaction fee a platform charges increases with the freshness utility and decreases with the base utility a monopolist offers (see Appendix 4.6.3):

$$\frac{\partial T^*}{\partial k} > 0, \frac{\partial T^*}{\partial v} < 0.$$

Similarly, the platform's profit is decreasing in the base utility, $\frac{\partial \pi_I}{\partial v} < 0$, and increasing in the freshness utility, $\frac{\partial \pi_I}{\partial k} > 0$.

Intuitively, if a product has a high (one-time) freshness utility, there will be a larger group of consumer willing to sell the used product for the second period. Consequently, the increased secondary market trading volume leads to an increase in the platform's transaction fee and profit. In contrast, a high base utility leads more consumers to keep their new product for the second period and decreases overall secondary market trading volume. Therefore, a platform asks for a lower transaction fee which results in a lower profit.

Numerical Example

Consider a monopolist with product characteristics $v = k = 10$. If a platform organizes the secondary market, the equilibrium outcomes are:

$$\begin{aligned} T &= 15/22 \approx 0.68, \\ p_n &= 315/22 \approx 14.32, \Delta_{p_n} = 0.32, \\ p_s &= 79/22 \approx 3.59, \Delta_{p_s} = 0.19, \\ \pi_M &= 3969/484 \approx 8.2, \Delta_{\pi_M} = 1.36, \\ \pi_I &= 9/22 \approx 0.41, \end{aligned}$$

where Δ captures the respective comparison between a flea market, with transaction costs $\tau^* = \omega^* = 1$, and a platform organized secondary market. The consumer fraction which stays inactive only changes slightly to $\theta_{so} \approx 0.43$. However, now thirty per cent of consumers either buy new and sell for both periods or buy used for both periods, i.e., $1 - \theta_{nk} = \theta_{ks} - \theta_{so} = 0.15$. The rest of consumers, $\theta_{nk} - \theta_{ks} \approx 0.27$, buys new once and keeps the used product.

The numerical example illustrates, that in comparison to any flea market with natural transaction costs $\omega^*, \tau^* > 0.68$ a platform leads, first, to more active consumers on both markets (increased market volume), second, to increased primary as well as secondary market prices and, third, to an increase in the monopolist's profit. In other words, the enhanced access for consumers to the secondary market, leads to more consumers buying used which subsequently increases prices and the monopolist's profit. The underlying reason is that the platform reinforces the valuation effect, by partly removing transaction costs. Thus, a monopolist may prefer a platform organizing the secondary market if it merely reduces natural search and waiting costs. The following remark summarizes the result.

Remark 1 *A platform that merely provides better access to the secondary market, i.e., partly removing transaction costs, strengthens the valuation effect and, consequently, increases the monopolist's profit.*

So far, I assumed homogeneous transaction costs. Heterogeneous natural transaction costs only lead to changes in the weight a platform places on each side of the market as well as to a reduction (increase) in the secondary market price when buyers (sellers) face higher natural transaction costs (see Appendix 4.6.2). For the sake of simplicity, I will focus in the following sections on the case where natural search and waiting costs are homogeneous.

4.3.3 Connecting Firms via the Platform

Most independent secondary market platforms do not only trade goods from one monopoly, but from several firms. An independent platform allows consumers to buy and sell used products from multiple firms on a single secondary market. To take a real world example: In the primary market for books, consumers usually have access to a limited number of firms. On the secondary market, however, platforms such as *Medimops* sell used books from all over the world. Thus, buyers and sellers on the secondary market are matched with secondary market buyers from other locations as well as with used products previously sold by bookshops they would not encounter on the primary market.

I assume that two firms $i \in [1, 2]$ are horizontally differentiated on the primary market in such a way that they are located at the extremes of a linear interval $[0, 1]$. This means that on the primary market half of the consumers buy from firm 1 and half of the consumers buy from firm 2. In other words, I assume that firms on the primary market still have some monopoly power due to spatial differentiation. In addition, I assume that the primary market is fully supported, i.e., there are always consumers on the interval who buy new.[16]

Similar to above, the equilibrium secondary market price is determined by the supply of all consumers who buy new every period on the primary market balancing the demand of the secondary market. However, now the second firm (indirectly) provides additional used products. In particular, the secondary market price adjusts in the following way:

$$(1 - \theta^1_{nk}) + (1 - \theta^2_{nk}) = (\theta^1_{ks} - \theta^1_{so}) + (\theta^2_{ks} - \theta^2_{so})$$
$$(1 - \frac{p_1 - 2p_s + 2T}{k}) + (1 - \frac{p_2 - 2p_s + 2T}{k}) = \frac{p_1 - 2p_s - 2T}{k} + \frac{p_2 - 2p_s - 2T}{k} - 2\frac{p_s + T}{v},$$

where prices on the respective primary market are p_i, with $i \in [1, 2]$. The left-hand side of the equation illustrates the supply of used products: Since the firms are symmetric, both firms face the same demand on the primary market from buyers who buy new in both periods and sell used products on the secondary market. The right-hand side of the equation shows the demand on the secondary market and consists of all consumers who buy used through the platform. Solving the equation leads to the secondary market price:

$$p_s = \frac{v(p_1 + p_2) - k(T + v)}{4v + k}. \tag{4.6}$$

[16] Alternatively, one could assume that firms are vertically differentiated in terms of their freshness utility, but once the product is used, products become indistinguishable. Another justification for this assumption is that most secondary market platforms allow for a quasi-perfect competition because all sellers of used products are equally allowed to enter. In contrast, primary market platforms allow firms to gain some market power for example by highlighting their products or making it difficult for consumers to compare all firms, see for example Ellison & Ellison (2009).

Both firms take the secondary market price into account and maximize their profit with respect to their individual primary market price:

$$\max_{p_i} D(p_i) \times p_i.$$

Solving for the first order condition yields primary market prices:

$$p_i = \frac{k(k + 2v - 2T)}{2(k + v)}. \tag{4.7}$$

The platform maximizes its profit, by choosing a transaction fee for sellers and buyers on the secondary market with respect to the trading volume induced:

$$\max_T 2\big((1 - \theta_{nk}^1) + (\theta_{ks}^1 - \theta_{so}^1) + (1 - \theta_{nk}^2) + (\theta_{ks}^2 - \theta_{so}^2)\big) \times T.$$

This leads to the equilibrium transaction fee:

$$T^* = \frac{k(k + 2v)^2}{4(3k^2 + 12kv + 8v^2)}. \tag{4.8}$$

The resulting equilibrium primary and secondary market price are:

$$\begin{aligned}
p_i^* &= \frac{k}{2(k + v)}(k + 2v - \frac{k(k + 2v)^2}{6k^2 + 24kv + 16v^2}),\\
p_s^* &= \frac{k(36kv^3 + 32v^4 - k^4 - 7k^3 v - 4k^2 v^2)}{4(k + v)(k + 4v)(3k^2 + 12kv + 8v^2)}.
\end{aligned}$$

The equilibrium profits for firms and the platform are:

$$\begin{aligned}
\pi_i^* &= \frac{k(k + 2v)^3(5k^2 + 22kv + 16v^2)^2}{8(k + v)^2(k + 4v)(3k^2 + 12kv + 8v^2)^2},\\
\pi_I^* &= \frac{k(k + 2v)^4}{2(k + v)(k + 4v)(3k^2 + 12kv + 8v^2)}.
\end{aligned}$$

A comparison between the optimal transaction fee T^* in the case of one firm, i.e., Equation (4.5), and in the case of two firms, i.e., Equation (4.8), leads to the following remark:

Remark 2 *If a platform connects two primary market monopolies on the secondary market, the platform asks consumers for a higher transaction fee T^*, in comparison to only allowing used products from a single primary market firm.*

See Appendix 4.6.4 for the detailed comparison. The platform can charge consumers higher transaction fees because consumers benefit from the indirect link between two primary market firms: Now, firms on the primary market can only monopolize the freshness utility. The base (utility) product is traded under a competitive setting. Therefore, primary and secondary market prices reduce significantly. The following remark summarizes the effect on the primary as well as the secondary market price:

Remark 3 *A platform that organizes the secondary market for a product offered by several firms with monopoly power leads to a decrease in the primary market and consequently secondary market prices, since the firms can only extract surplus from consumers who are willing to pay for freshness utility k.*

The detailed comparison of primary market prices, i.e., Equation (4.2) and Equation (4.7), is illustrated in the Appendix 4.6.4. In particular, firms can only extract surplus regarding their freshness utility k, since consumers can gain base utility v in a quasi perfect competitive setting: On the one hand, if a firm i asks for a higher price on the primary market $p_i > p_j$, it directly looses consumers which switch from buying new to keeping, or buying new to buying used. On the other hand, firm i looses primary market consumers because the additional (cheaper) supply of the other firm j drastically reduces the valuation effect of the secondary market. Because used products are perfect substitutes to each other, the result is irrespective of the number of firms operating on a separate (horizontally differentiated) primary market while being connected via the secondary market platform.

To give an intuition, consider again the market for books: If a bookshop can monopolize both the primary and the secondary market, i.e., only used books from one bookshop are sold on the secondary market, the bookshop benefits uniquely from the valuation effect of used books. Once an independent platform organizes the secondary market where used books from multiple bookshops can be traded, the valuation effect vanishes since the platform induces competition regarding the base valuation. The shared secondary market induces competitive pricing in the primary market even though primary markets are separate. Thus, the competitive secondary market cannibalizes the profits of the primary market. Remark 4 summarizes the valuation and cannibalization effect of shared secondary markets:

Remark 4 *If the secondary market is open to used products of multiple firms, the valuation effect a primary market firm can capitalize on is starkly reduced. Now the secondary market mainly cannibalizes primary market profits.*

Numerical Example

To follow the numerical example of the last sections, the equilibrium outcome of two firms providing a product with $v = k = 10$ to two separated primary markets, which are connected via the secondary market is:

$$T = 45/46 \approx 0.98, \Delta_T = 0.3,$$
$$p_i = 645/92 \approx 7.01, \Delta_{p_i} = -7.31,$$
$$p_s = 14/23 \approx 0.61, \Delta_{p_s} = -2.98,$$
$$\pi_i = 49923/8464 \approx 5.9, \Delta_{\pi_i} = -2.3,$$
$$\pi_I = 243/184 \approx 1.32, \Delta_{\pi_I} = 0.91,$$

where Δ is the respective comparison between a platform that allows used products from one or two primary market firms. Both primary and secondary market prices decrease significantly, which also reduces the profit of the primary market firms. The decreased prices induce more consumers to stay active on the respective markets: The consumer fraction which buys new for two periods or buys used for both periods is $1 - \theta^i_{nk} = \theta^i_{ks} - \theta^i_{so} = 0.225$. Only around 16 per cent, $\theta_{so} = 0.158$, of all consumers stay inactive. The remaining consumers buy used and keep, $\theta_{nk} - \theta_{ks} \approx 0.39$.

The results highlight that firms prefer a closed secondary market platform or the complete closure of the secondary market.[17] Otherwise, a shared secondary market cannibalizes the monopolist's profit by intensifying the competition regarding the base valuation. Real world examples, such as the secondary market of Zalando or Zara, show that firms already establish closed secondary markets. These firms only allow consumers to sell and buy used products previously sold new by the same firm. Remark 5 completes this section:

Remark 5 *Once secondary market platforms connect firms, a monopolist prefers a closed secondary market, or no secondary market at all.*

[17] A monopolist is also better off if there is no secondary market, see the first result of section 3.1.2.

4.3.4 Connecting Consumers via the Platform

Platforms not only connect firms, they also connect consumers to the secondary market. In particular, I argue that the second central function of a platform is to inform consumers about the secondary market as a shopping alternative. For example, platforms, such as *Ebay, Rebuy* or *Vinted*, advertise to consumers the benefit of reselling or buying second hand products. In what follows, I will show that a monopolist serving two types of consumers, attentive and inattentive, can only profit from platforms and secondary markets if the majority of consumers are sufficiently attentive in the first place.

I begin by explaining the basic trade-off a monopolist faces in the presence of extremely inattentive consumers. The main difference to before is that unaware consumers lead to a modified primary market price mechanism. With inattentive consumers who stay inactive or buy new every period the cannibalization effect cannot be compensated for by the valuation effect. I then illustrate that the valuation effect can balance the cannibalization effect once consumers become sufficiently attentive, i.e., taking into consideration to keep a new product for the second period.

Inattentive Consumers

I assume that some consumers do not consider the secondary market at all. Let $\alpha \in [0, 1]$ denote the fraction of consumers who pay attention to both markets. Conversely, let $1 - \alpha$ be the inattentive fraction of consumers who only consider the primary market. For now, I assume that the inattentive fraction of consumers faces the following reduced consumption choice: Consumers either buy new every period, or stay inactive. The utility functions of inattentive consumers over two periods are:

$$\bar{U}_n = 2(\theta(v + k) - p_n),$$
$$\bar{U}_0 = 0.$$

Because inattentive consumers do not consider the secondary market, their utility is independent of secondary market prices. The two inattentive consumer groups can then be characterized by:

$$\bar{\theta}_{no} = \frac{p_n}{v + k}.$$

A group of inattentive consumers, $1 - \bar{\theta}_{no}$, buys always new. The rest of inattentive consumers, $\bar{\theta}_{no}$, stays inactive. The attentive consumer fraction remains similar to beforehand, see Section 4.3.1. In contrast to above, the primary market price mechanism changes, since the primary market demand is also influenced by inattentive consumers, according to:

$$D(p_n) = \alpha\big(2(1 - \theta_{nk}) + (\theta_{nk} - \theta_{ks})\big) + (1 - \alpha)2(1 - \bar{\theta}_{no}).$$

If there are only inattentive consumers, i.e., $\alpha = 0$, there exists no secondary market since no consumer is aware of reselling or buying used. The top side of Figure 4.4 illustrates this situation, i.e., the one side of consumers stays inactive and the other side buys new for both periods. The equilibrium outcome in such a market is characterized by:

$$p_n^0 = (k+v)/2,$$
$$\pi_M^0 = (k+v)/2.$$

In contrast, if every consumer is attentive, i.e., $\alpha = 1$, and a platform is organizing the secondary market, the market outcome is:

$$p_n^1 = \frac{k+2v-2T}{2},$$
$$\pi_M^1 = \frac{(k+2v-2T)^2}{2(k+4v)},$$

where $T = k(k+2v)/4(3k+8v)$ is the transaction fee chosen by the platform. The bottom side of Figure 4.4 illustrates this situation. A comparison of the monopolist's profit yields $\pi_M^0 > \pi_M^1$. The monopolist's profit with inattentive consumer is higher compared to attentive consumers (see Appendix 4.6.5 for the detailed comparison).

Numerical Example

Consider again the case for a monopolist producing a product with $v = k = 10$. Then, Figure 4.5 shows the market outcome over all possible attention levels.

Obviously, the monopolist's profit is maximized for complete inattention ($\pi_M^0 = 10 > 8.2 = \pi_M^1$). With increasing attention, $\alpha \to 1$, more and more consumers become aware of the valuation effect. In other words, more consumers buy and sell on the secondary market. As a result, the monopolist can raise primary prices, which in turn leads to an increase in secondary market prices. However, the valuation effect does not counter the effect of consumers keeping a used product: Figure 4.4 clarifies that of all consumers who where previously inattentive, a substantial part becomes attentive and starts to keep for the second period instead of buying new again. Thus, irrespective of industry characteristics, a monopolist prefers inattentive consumers if inattentive consumers do not consider to keep their product. Remark 6 summarizes this:

Remark 6 *For inattentive consumers who only buy new or stay inactive, a monopolist prefers full inattention to attention, since the valuation effect cannot compensate for the cannibalization effect. As attention increases, a significant proportion of previously inattentive consumers start to keep for the second period instead of buying new twice.*

Inattentive Keepers

So far I have assumed an extreme specification of inattention. If some inattentive consumers also decide to keep a new product, their consumption options are characterized by:

$$\bar{U}_n = 2(\theta(v+k) - p_n),$$
$$\bar{U}_k = \theta(2v+k) - p_n,$$
$$\bar{U}_0 = 0.$$

Consequently, inattentive consumers can be grouped according to:

$$\bar{\theta}_{nk} = \frac{p_n}{k}, \bar{\theta}_{ko} = \frac{p_n}{2v+k}.$$

$1-\bar{\theta}_{nk}$, of inattentive consumers buy new for both periods. A group of $\bar{\theta}_{nk}-\bar{\theta}_{ko}$ buys new for the first period and keeps the product for the second period. The rest of the inattentive consumers, $\bar{\theta}_{ko}$, stays inactive. This changes the primary market demand function in the following way:

If $p_n < k$, i.e., some inattentive consumers are willing to buy new twice, $\bar{\theta}_{nk} < 1$, the primary market demand is:

$$D(p_n) = \alpha(2(1-\theta_{nk}) + (\theta_{nk} - \theta_{ks})) + (1-\alpha)(2(1-\bar{\theta}_{nk}) + (\bar{\theta}_{nk} - \bar{\theta}_{ko})).$$

If $p_n \geq k$, i.e., no inattentive consumer is willing to buy new twice, $\bar{\theta}_{nk} \geq 1$, the primary market demand is:

$$D(p_n) = \alpha(2(1-\theta_{nk}) + (\theta_{nk} - \theta_{ks})) + (1-\alpha)(1-\bar{\theta}_{ko}).$$

For the extreme level of full attention, i.e., $\alpha = 1$, the above analysis remains the same. However, the extreme case of full inattention , i.e., $\alpha = 0$, changes. The equilibrium outcome of the primary market and monopolist's profit is:

$$p_n^0 = \frac{k(k+2v)}{2(k+v)},$$
$$\pi_M^0 = \frac{k(k+2v)}{2(k+v)}.$$

Now, the comparison of π_M^0 and π_M^1 yields a different result: Dependent on the industry characteristics the monopolist prefers a platform which informs consumers about secondary market characteristics, or no platform at all. If the freshness and base utility relationship is such that $k > 2v$, it is always true that $\pi_M^0 > \pi_M^1$. Even if the platform charges no transaction costs, the monopolists prefers inattentive consumers. Otherwise, if the freshness and base utility is such that $k << 2v$ the monopolist benefits from a platform making consumers attentive, i.e., $\pi_M^0 < \pi_M^1$. For example, for all $k \leq \frac{6}{5}v$, the monopolist prefers fully attentive consumers to inattentive consumers. The following remark captures this result (see Appendix 4.6.5 for the detailed comparison).

Remark 7 *If some inattentive consumers keep their product, the monopolist prefers a platform organizing the secondary market and making consumers aware of secondary market opportunities, only if the freshness and base utility ratio are sufficiently balanced, i.e., $k << 2v$.*

The intuition behind this result is that the secondary market price decreases with increasing freshness utility (holding the base utility constant). Thus, within an industry where the freshness utility is very high compared to the base utility the secondary market primarily cannibalizes primary market profits. The following numerical example illustrates the case of an industry with $k << 2v$ and clarifies the result with inattentive consumers who also may keep their product for the second period.

Numerical Example

Figure 4.7 shows the market outcome over all possible attention levels with $v = k = 10$. First, it is straightforward to see, that the monopolist prefers maximum attention ($\pi_M^0 = 7.5 < 8.2 = \pi_M^1$). As a result of increasing attention, more and more consumers become aware of the valuation effect and buy or sell on the secondary market. As before, the monopolist can raise primary market prices which also increases the secondary market price. However, for $\bar{\alpha}$ where $k = p_n$, there exist no more inattentive consumers who buy new for both periods, i.e., $\bar{\theta}_{nk} = 1$. The valuation effect accounted for by attentive consumers, prices out inattentive consumers who buy always new. Thus, the monopolist can now ask for higher prices. This causes the jump in the monopolist's profit, secondary market prices and primary market prices. A monopolist's profit is strictly increasing from this point, since a significant part of inattentive consumer would buy new for both periods, if they would be aware of the secondary market, see Figure 4.6. Notice, that this result is dependent on the platform ensuring a full (or a high level of) attention towards the secondary market.

Second, for low attention levels, the monopolist's profit decreases. As before, the increase in the primary market price cannot compensate for the fact that more inattentive consumers are switching from keeping to staying inactive and from buying always new to keeping, see Figure 4.6. The reduction in overall demand, $D(p_n)$ for $p_n < k$, is not balanced by the increase in price due to the valuation effect. However, in contrast to before, the cannibalization effect is far less pronounced because (some) inattentive consumers already keep their product for the second period. Thus, if a platform can only raise attention towards low levels of attention, in particular $\alpha < \bar{\alpha}$, a monopolist may prefer that consumers remain inattentive towards secondary markets. Remark 8 summarizes this finding.

Remark 8 *If a platform can only guarantee low levels of attention, a monopolist prefers inattentive consumers or no platform at all, even if the industry characteristics are sufficiently balanced, i.e.,* $k << 2v$.

In summary a monopolist only prefers a platform which connects inattentive consumers to the secondary market, if some inattentive consumers consider to keep their product for the second period and if the platform can guarantee a sufficient level of attention towards the secondary market.

Remark 9 *A monopolist only profits from a platform if consumers are sufficiently attentive in the first place. A platform connecting inattentive consumers to the secondary market may increase the monopolist's profit only if inattentive consumers consider to keep instead of buying new.*

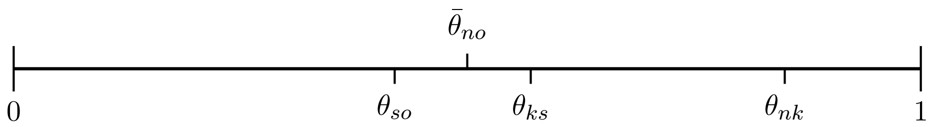


Figure 4.4: Consumer groups when inattentive consumers always buy new or stay inactive (top) vs. attentive consumer groups (bottom).

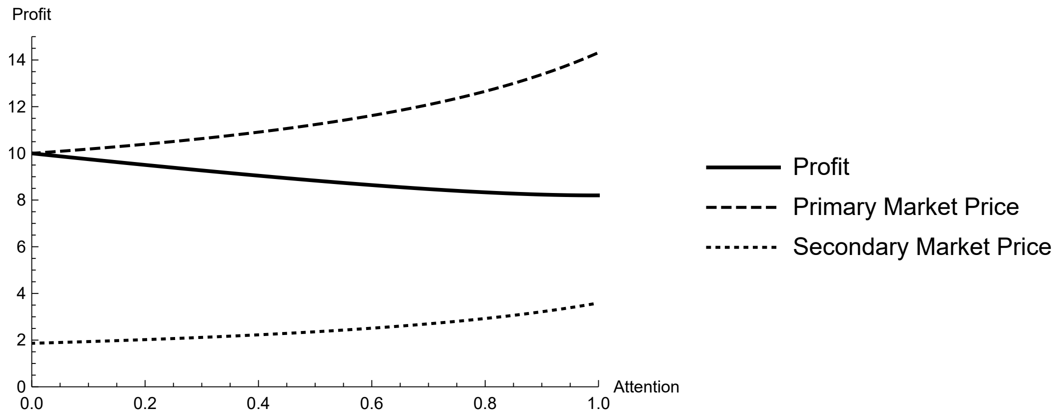


Figure 4.5: Equilibrium outcome with $k = v = 10$, when inattentive consumers always buy new or stay inactive.

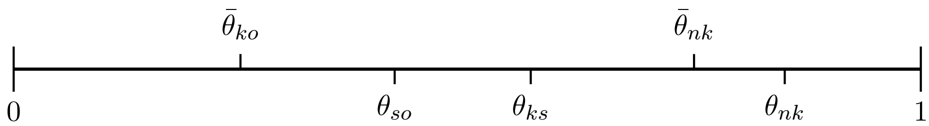


Figure 4.6: Consumer groups when inattentive consumers buy new, keep or stay inactive (top) vs. attentive consumer groups (bottom).

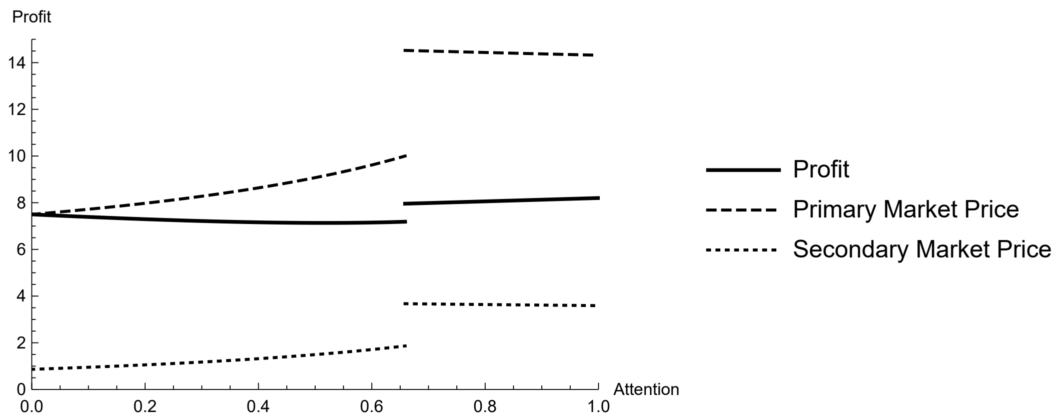


Figure 4.7: Equilibrium outcome with $k = v = 10$, when inattentive consumers buy new, keep or stay inactive.

4.4 Discussion

The recent development that secondary markets are more and more often organized by platforms or other intermediaries may vary the monopolist's preference for a secondary market, see Remarks 1 - 9. In general, a monopolist prefers low transaction costs, which a platform can provide. As soon as a platform fulfills additional features, such as allowing other used products on the secondary market or advertising to inattentive consumers the options of secondary markets, a monopolist preference for secondary markets shifts.

Throughout the analysis I have assumed that consumers are uniformly distributed on the interval $\in [0, 1]$. A modification of this assumption would change the model in the following way: On the one hand, the secondary market mechanism would need to be redefined, because dependent on the distribution there might be excess secondary market demand or supply. On the other hand, the platform would charge buyers and sellers different transaction costs, because one side of the market is now more beneficial. Lastly, if consumers are not uniformly distributed, the intermediaries type does matter. The main results, however, remain unaffected by this change. In summary, a departure from this assumption would make the model less tractable, but not lead to fundamentally different insights.

In addition, I only discussed the existence of one platform. Yet, usually there exist multiple platforms for the secondary market, which may compete with each other for consumers. If one introduces platform competition in the model, this fundamentally changes the optimal transaction fee. Platforms would set transaction fees close to zero in order to attract consumers. However, as long as platforms connect several firms and inattentive consumers to the secondary market, the above result should hold.

There exist also various reasons for using the secondary market other than those assumed in the model. For example, in today's economy there are multiple other drivers for secondary markets such as ecological and fashion concerns. Such preferences are not accounted for by the model. Thus, it would be interesting to follow up on other reasons for the existence of secondary markets in future research.

Whereas the majority of the empirical literature examines the used markets for cars, i.e., where the product has a high base utility, today, secondary markets become especially relevant for industries such as the smartphone or fashion industry. Thus, with respect to industry characteristics, the current development of secondary markets may illustrate that attentive consumers in general put more weight on base utility compared to freshness utility. Consequently, Remark 7 may not apply anymore. Instead, it becomes more important that a platform can guarantee high levels of attention, see Remark 8, to make a secondary market beneficial for a monopolist.

Moreover, in today's economy, an increasing number of firms across various industries engages by themselves on the secondary market, instead of leaving the secondary market to platforms, e.g., firms such as *Zara* and *Zalando*. In other words, some primary market firms start to organize the secondary market themselves. Arguably, such firms try to remove transaction costs for consumers to strengthen the valuation effect, see Remark 1. However, simultaneously firms try to circumvent the downsides of platform features, such as additional competition, see Remark 4.

Finally, secondary markets become especially important with respect to the recent debate about resource scarcity. Hence, form a policy perspective a state authority can take different measurements to improve the secondary market development. Through legislation such as the *Right to Repair*, a state authority can ensure that consumer can gain a sufficiently high base utility and that a monopolist may profit from secondary markets. In other words, such laws ensure the existence of secondary markets by strengthening the valuation effect. Moreover, state authorities can inform consumers about secondary market opportunities. Lastly, competition authorities can ensure that the secondary market is accessible to various firms.

4.5 Conclusion

I have studied a model of secondary markets, where the secondary market is organized by a platform. A platform's capability to reduce transaction costs is beneficial for a monopolist operating in the primary market. However, as soon as a platform fulfills additional features a monopolist may prefer a closed secondary market, or no secondary market at all.

If a platform connects various primary market firms via the secondary market, the monopolist's profit reduces starkly since the valuation effect is competed away. A monopolist thus only benefits from a secondary market that uniquely trades its products. I also show that a monopolist only desires a secondary market platform if the industry characteristics are balanced and if the platform can guarantee high consumer attention levels. If a large number of consumers is inattentive towards the secondary market, a monopolist prefers to shut down the secondary market irrespective of the industry characteristics.

In light of the recent debate about resource scarcity, market authorities should therefore closely monitor the access and information of secondary markets. Monopolists may otherwise aim to obfuscate secondary market opportunities and shut down the secondary market.

4.6 Appendix

4.6.1 Distribution of the Platform's Transaction Fee

Let the natural transaction costs of buyers and sellers in the secondary market be homogeneous and let the platform's profit be defined by:

$$\pi_I = 2\big(\omega \times (1 - \theta_{nk}) + \tau \times (\theta_{ks} - \theta_{so})\big),$$

where ω is the transaction fee paid by sellers and τ is the transaction fee paid by buyers on the secondary market. Then,

$$\pi_I = 2\big(\omega \times (1 - \frac{p_n - 2p_s + \omega}{k}) + \tau \times (\frac{p_n - 2p_s - 2\tau}{k} - \frac{p_s + \tau}{v})\big),$$

where

$$p_s = \frac{2vp_n - k(v + \tau) + 2v(\omega - \tau)}{2},$$
$$p_n = \frac{k + 2v - \tau - \omega}{2}.$$

The platforms' first order conditions with respect to transaction fees, then lead to:

$$\frac{\partial \pi_I}{\partial \omega} = \frac{k^2 - 6k\tau + 2kv - 16v\tau}{6k + 16v} = 0$$

and

$$\frac{\partial \pi_I}{\partial \tau} = \frac{k^2 - 6k\omega + 2kv - 16v\omega}{6k + 16v} = 0$$

Therefore, in equilibrium, a platform will charge sellers and buyers on the secondary market equally, i.e., $\tau = \omega = T$.

4.6.2 Heterogeneous Natural Transaction Cost

If natural search or waiting costs differ between buyers and sellers of the secondary market, the platform adjusts its behaviour accordingly. Let us start with the case where sellers of used products face no or very low natural waiting costs, i.e., $\omega^* = 0$. First, prices on the secondary market adjust to:

$$p_s = \frac{2vp_n - k(\tau + v) - 2v\tau}{4v + k}.$$

Second, as a consequence the monopolist sets a primary market price of:

$$p_n = \frac{k + 2v - \tau}{2}.$$

Since a platform that asks for a transaction fee $T > \omega^*$ does not attract any sellers of used products, the platform maximizes the new profit function:

$$\begin{aligned}\pi_I &= 2(\theta_{ks} - \theta_{so}) \times T, \\ &= 2(\frac{p_n - 2p_s - 2T}{k} - \frac{p_s + T}{v}) \times T.\end{aligned}$$

Solving for the profit maximizing transaction fee yields:

$$T^* = \frac{k(k + 2v)}{(6k + 16v)}. \tag{4.9}$$

Comparing a one-sided optimal transaction fee, Equation 4.9, to a two-sided transaction fee, Equation 4.5, reveals that the platform simply levies the missing income from sellers on to buyers of the secondary market. Buyers in the secondary market now have to pay a transaction fee that is twice as high as before. Since total transaction fees remain constant, the primary market price is unaffected by the change in transaction fees. However, the equilibrium secondary market price decreases by half the transaction fee, i.e., $T^*/2$, because the burden of paying the transaction fee lies uniquely with buyers on the secondary market. In other words, sellers on the secondary market have to forgo some profit in order to incentivise buyers to pay a higher transaction fee and visit the secondary market platform. If natural transaction costs are lower for secondary market buyers, the result is reversed. Coming back to the numerical example, the only variation in outcome concerns the transaction fee, now $T = 1.36$, and the respective secondary market price, $p_s = 2.91$ if $\omega = 0$, or $p_s = 4.27$ if $\tau = 0$.

4.6.3 Transaction Fee - Industry Dynamics

In equilibrium a platform asks sellers and buyers for transaction fee:

$$T = \frac{k(k+2v)}{4(3k+8v)}. \tag{4.10}$$

The first order condition with respect to base utility v yields:

$$\frac{\partial T}{\partial v} = \frac{2k \times 4(3k+8v) - k(k+2v) \times 32}{(4(3k+8v))^2} = 0$$

Since $(4(3k+8v))^2 > 0$,

$$\begin{aligned} 2k \times 4(3k+8v) - k(k+2v) \times 32 &= 0 \\ 24k^2 + 64vk - 32k^2 - 64vk &= 0 \\ -8k^2 &< 0 \end{aligned}$$

The first order condition with respect to freshness utility k yields:

$$\frac{\partial T}{\partial k} = \frac{(2k+2v) \times 4(3k+8v) - k(k+2v) \times 12}{(4(3k+8v))^2} = 0$$

Since $(4(3k+8v))^2 > 0$,

$$\begin{aligned} (2k+2v) \times 4(3k+8v) - k(k+2v) \times 12 &= 0 \\ 24vk + 24k^2 + 64v^2 + 64vk - 12k^2 - 24vk &= 0 \\ 12k^2 + 64(v^2 + vk) &> 0 \end{aligned}$$

4.6.4 Transaction Fee - Connecting Firms

The transaction fees a platform chooses with one and two firms are defined by Equation 4.5 and Equation 4.8 respectively:

$$\begin{aligned}
T_1 &= \frac{k(k+2v)}{4(3k+8v)} \\
T_2 &= \frac{k(k+2v)^2}{4(3k^2+12kv+8v^2)}.
\end{aligned}$$

The comparison of the two transaction fees reveals that $T_1 < T_2 \ \forall k \geq 0, v > 0$:

$$\begin{aligned}
T_1 &< T_2 \\
\frac{k(k+2v)}{4(3k+8v)} &< \frac{k(k+2v)^2}{4(3k^2+12kv+8v^2)} \\
1 &< \frac{(k+2v)(3k+8v)}{3k^2+12kv+8v^2} \\
1 &< \frac{3k^2+8kv+6kv+16v^2}{3k^2+12kv+8v^2} \\
1 &< \frac{3k^2+12kv+8v^2}{3k^2+12kv+8v^2} + \frac{2kv+8v^2}{3k^2+12kv+8v^2} \\
0 &< \frac{2kv+8v^2}{3k^2+12kv+8v^2}
\end{aligned}$$

The comparison of primary market prices reveals that $p_i < p_n$:

$$\begin{aligned}
p_i &< p_n \\
\frac{k(k+2v-2T_2)}{2(k+v)} &< \frac{k+2v-2T_1}{2} \\
k^2+2kv-kT_2 &< (k+v)(k+2v-2T_1) \\
-2kT_2 &< kv+2v^2-2kT_1-2vT_1 \\
0 &< kv+2v^2-2vT_1+2k(T_2-T_1) \\
0 &< 2v^2 + \frac{5k^2v+14kv^2}{2(3k+8v)} + 2k(T_2-T_1)
\end{aligned}$$

Since $T_2 - T_1 > 0$, see above, it follows that $p_i < p_n$.

4.6.5 Comparison Inattentive - Attentive Consumer

No Inattentive Keepers

The monopolist's profit with only inattentive consumers $\alpha = 0$ and only attentive consumers $\alpha = 1$ is

$$\pi_M^0 = \frac{k+v}{2}$$
$$\pi_M^1 = \frac{(k+2v-2T)^2}{2(k+4v)}$$

For now, assume that the platform does not charge consumers, i.e., $T = 0$, then:

$$\begin{aligned}
\pi_M^0 &= \pi_M^1 \\
\frac{k+v}{2} &= \frac{(k+2v)^2}{2(k+4v)} \\
(k+4v)(k+v) &= (k+2v)(k+2v) \\
k^2 + vk + 4vk + 4v^2 &= k^2 + 4vk + 4v^2 \\
kv &= 0
\end{aligned}$$

Thus, also for any $T > 0 \rightarrow \pi_M^0 > \pi_M^1$.

Inattentive Keepers

The monopolist's profit with inattentive consumers, where some inattentive consumers also keep their new product, is:

$$\pi_M^0 = \frac{k(k+2v)}{2(k+v)}.$$

The monopolist's profit with fully attentive consumers, remains the same:

$$\pi_M^1 = \frac{(k+2v-2T)^2}{2(k+4v)}.$$

For the sake of tractability, I again assume that the platform does not charge any transaction fee, i.e., $T = 0$. Then, the global comparison of profits yields $\pi_M^0 > \pi_M^1$ if $k > 2v$:

$$\begin{aligned}
\pi_M^0 &= \pi_M^1 \\
\frac{k(k+2v)}{2(k+v)} &= \frac{(k+2v)^2}{2(k+4v)} \\
\frac{k}{k+v} &= \frac{(k+2v)}{k+4v} \\
k(k+4v) &= (k+v)(k+2v) \\
k^2 + 4vk &= k^2 + 3vk + 2v^2 \\
k &= 2v
\end{aligned}$$

Thus, for $T = \frac{k(k+2v)}{4(3k+8v)}$ a monopolist's only prefers full attention i.e., $\pi_M^1 < \pi_M^0$, if freshness utility ratio is sufficiently balanced, i.e., $k << 2v$. For example if $k = \frac{6}{5}v$ and $T = \frac{k(k+2v)}{4(3k+8v)}$, then:

$$\pi_M^0 < \pi_M^1$$
$$0.872727v < 0.885393v$$

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