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Prominence and Reputation in Online Markets

Doctoral Dissertation presented by

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in fulfillment of the requirements
for the degree of Doctor in Economics and Management

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Louvain-la-Neuve, Belgium
September, 2023

Without competition we'd still
be single-cell organisms.
— Dr. H.

Acknowledgements

I am profoundly grateful to all the people who have supported and accompanied me on this doctoral journey.

First and foremost, I want to emphasize my deep gratitude to my supervisor, Paul Belleflamme. He has guided me throughout my doctoral studies, providing invaluable feedback and insights. His support enabled me to fully embrace the doctoral experience by allowing me to be autonomous in my research, nurturing my ideas and projects, and helping me obtain funds for my studies and travels. Our engaging conversations and discussions on digital markets have been a highlight, and I will forever appreciate the time and kindness he devoted to me.

I also sincerely thank Johannes Johnen for his helpful suggestions and mentorship. I am immensely grateful to Marc Bourreau, Axel Gautier, and David Ronayne for their support and welcoming me into their home institutions. I learned a lot from interacting with them, and my work has tremendously improved thanks to their comments. I could not have hoped for a better doctoral committee.

I am thankful for the incredible Digital Economics community I had the privilege of being a part of. Special thanks to Alexandre, Elias, Flavio, Francesco, Grazia, Luca, Luise, Marita, Michelangelo, Özlem, and Willy for our enriching interactions and memorable moments.

I owe a debt of gratitude to Axel Desmedt and Alexandre de Streel for their genuine support and for helping secure the FRESH fellowship. Additionally, I extend my thanks to FNRS for their generous financing of my doctoral studies. I also wish to express my appreciation to Catherine Germain, Marie Gonze, and Margaux Hubin for their assistance in navigating the intricacies of the Louvain

bureaucracy.

From the very beginning of my doctorate, I was fortunate to collaborate with exceptional co-authors. Leonardo, in particular, has been an invaluable source of assistance and knowledge throughout this journey. His enthusiasm and passion have been a constant source of inspiration, and I consider myself lucky to call him one of my closest friends. I am equally fortunate to have met Eliza, with whom I started a lasting friendship and a fruitful collaboration, and I thank Lars for his guidance in our work together.

My doctoral journey would not have been as fulfilling without the incredible colleagues I had the privilege of meeting in Louvain. I thank Erika for her constant friendship and support over the past five years, Valerio for injecting humor and spontaneity into my life, Sonia for her kindness, Frank for his valuable advice and friendship, Daniele for encouraging me to embark on this doctoral adventure, and Adam for his companionship. I am grateful to Angelo, Antoine, Arnaud, Francesco, Hassan, Huan, Laura, Lorenzo, Martial, Matteo, Muxin, Niranjana, Tiziano, Thomas, Rim, Robin, Sabina, Sefane, and all the other wonderful colleagues at CORE, IRES and LFIN for their camaraderie and the enriching conversations we shared during our coffee breaks.

My deepest gratitude goes to my parents, Albertina and Giancarlo, to Philippe, and to my brother Valerio for their unwavering support and boundless love. Thank you for believing in me and encouraging me when I felt lost.

Lastly, I am immensely thankful to CORE for not only contributing to my academic growth but also for playing a role in my personal life by allowing me to find love. Thank you, Mariam, for your patience, care, love, and ability to brighten my every day.

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Introduction

Over the past decades, the digital economy has undergone tremendous growth. The advent of the Internet fundamentally reshaped how we interact and conduct business. Online platforms were able to harness the potential for innovation in the digital economy, introducing new technologies and services that benefit consumers and businesses. However, a small group of online platforms has emerged as dominant players in the digital sector, even ranking among the world's most highly capitalized firms.[1] This concentration of wealth and power in few online platforms has created substantial barriers to entry for new players, which, in turn, hinder the ability of potential competitors to challenge the established online platforms effectively. In many cases, new entrants either exit the market or become acquired by the dominant platforms,[2] further reinforcing their position. Additionally, these barriers are closely tied to the size of the network effects exploited by the digital intermediaries and the scope of their online ecosystems. This phenomenon often leads to winner-takes-all situations, where a single platform emerges as the dominant player in a specific industry.

In response to growing concerns over the dominant position of several online platforms, influential policy reports (ACCC, 2019; Crémer et al., 2019; Furman et al., 2019; Scott Morton et al., 2019) highlighted the need for action, and public authorities have recently taken steps to address these issues. The European Commission (EC) has been at the forefront of this movement, initiating a series of online market regulations. The primary objective of these regulations is to safeguard consumers and restore a level

[1] Out of the top 10 firms by market capitalization, five are digital platforms: Google, Apple, Facebook, Amazon, and Microsoft Statista.com (2022), the so-called "GAFAM".

[2] The most notable examples are the acquisitions of Instagram and WhatsApp by Facebook.

playing field in online markets. The first significant measure implemented by the EC was the introduction of the General Data Protection Regulation (GDPR) in 2018. The GDPR aims to protect user data while enabling its transfer across platforms. Additionally, in 2020, the platform-to-business (P2B) regulation was enacted, prohibiting unfair contracts and requiring greater transparency regarding platform ranking practices. In 2022, the Digital Service Act (DSA) and the Digital Market Act (DMA) were approved by the European Parliament. The DSA addresses platforms' liability for hosted content, products, and algorithms. The DMA explicitly targets the largest online platforms, referred to as "gatekeepers", and establishes a set of obligations and rules to prevent the abuse of their dominant position, such as discouraging self-preferencing and harmful bundling practices. Looking forward, the EC is also working on a legal framework to regulate the rapidly expanding field of artificial intelligence, where significant market concentration is already apparent.

This thesis focuses on digital marketplaces, which serve as platforms connecting and matching online users while facilitating transactions between them. The study of online marketplaces is particularly intriguing because they assume the role of regulators within their virtual environments by establishing rules for user interactions. Various types of online marketplaces exist, each specializing in a specific industry. For instance, Amazon and eBay operate in general retail, Airbnb and Booking.com focus on the accommodation market, while Apple's App Store and Google's Play Store cater to the app market. Despite their industry-specific nature, these marketplaces share common functionalities and derive their purpose from assisting consumers in navigating extensive product listings by making some firms more prominent and mitigating information asymmetries through reputation systems. However, such intermediaries are also "*able to act as a gatekeeper between businesses and their prospective customers. This gives the platforms three distinct forms of power: the ability to control access and charge high fees; the ability to manipulate rankings or prominence; and the ability to control reputations*" (Furman et al., 2019).

Online marketplaces have the ability to influence consumer behavior through the use of prominence, which can take various forms. Traditionally, intermediaries have the power to determine the visibility of firms by manipulating their ranking in search results. They can also strategically display information on the website or use recommendations to affect how

consumers compare products. Digital marketplaces have introduced innovative methods of assigning prominence through algorithms. These algorithms consider multiple dimensions of firms, assigning different weights to each, and ultimately decide which firm is displayed to consumers. However, the inner workings of these algorithms are often kept confidential, and firms are unaware of the specific actions they need to take to obtain prominence. This secrecy also creates opportunities for platforms to manipulate their algorithms in ways that may be considered unfair. For instance, there may be incentives to systematically favor a particular firm based not on match value, quality, or price but on hidden agreements or because the platform owns the favored firm (i.e., self-preferencing). As profit-maximizing entities, marketplaces may utilize prominence to distort competition in their favor. A clear example is position auctions, where the highest bidder secures a prominent placement. However, the highest bidder may be ill-suited for consumers. Therefore, the interests of the intermediary and consumers may not be aligned.

Online marketplaces heavily rely on reputation systems to foster trust among participants. These systems utilize ratings and comments from previous consumers, aiding consumers in making informed purchasing decisions and enabling firms to showcase their quality. However, platforms have complete control over how reputation systems operate, including design choices, rating permissions, and the ability to filter or delete comments and ratings. These decisions significantly impact market dynamics and the well-being of businesses reliant on reputation scores to attract consumers. Public authorities have expressed concerns regarding the potential for reputation systems to induce lock-in effects that reinforce online gatekeepers' entrenched position. Indeed, firms may be reluctant to switch platforms if it means losing their established reputation on a particular platform.

This thesis aims to enhance our understanding of the novel business practices employed by online marketplaces to govern their ecosystems and how these practices influence competition and the welfare of users within the platform. Furthermore, it seeks to provide valuable insights from both policy and managerial perspectives. This thesis is structured into three chapters. The first two chapters examine issues related to prominence, while the third chapter analyzes the role of reputation systems.

Chapter 1 analyzes the business strategy employed by major online marketplaces, such as Amazon, which involves grouping all the offers

associated with a particular product on a single webpage and designating a default retailer prominently displayed in the "buy-box". Meanwhile, other retailers are presented in less prominent areas, below the buy-box or on a separate webpage. Since most purchases are made through the buy-box, it is crucial for retailers to gain prominence. This chapter addresses how selecting a default retailer affects competition among retailers and whether this business strategy benefits the intermediary and consumers. Unlike previous studies on prominence, the contribution of this chapter lies in analyzing how prominence is endogenously allocated via a non-monetary instrument in a setting where retailers offer different qualities in terms of purchasing experience, and some consumers are unaware of alternative offers outside the buy-box.

The main result is that an intermediary can use prominence to induce retailers to fiercely compete for the buy-box. In this equilibrium, the low-quality retailer serves no consumers but plays a crucial role in compelling the high-quality retailer to lower its price and expand demand. In turn, this strategy benefits consumers by providing access to a lower-priced high-quality product while optimizing the intermediary's overall profits. The findings provide an explanation for why major retail marketplaces, such as Walmart in the United States or Bol.com in the Netherlands, following Amazon's example, have also adopted a platform business model that enables third-party sellers to operate on their marketplace and compete for their version of the buy-box.

This chapter was inspired by the concerns raised by antitrust authorities for possible suspected anti-competitive practices related to Amazon's buy-box. At the end of 2022, Amazon settled the European Commission's investigations by offering, among other commitments, to display a second competing offer to the Buy Box winner.[3] Our findings suggest that the commitment proposed may only partially address the surplus extraction issue that can arise from the assignment of a buy-box. The criteria used by the intermediary may still stimulate fierce competition among retailers and allow for monopolistic rent extraction through its fee structure. Hence, thoughtful consideration and thorough evaluation are necessary to devise prominence allocation schemes to optimize market outcomes and maximize welfare for all participants.

Chapter 2 explores another dimension of prominence within online marketplaces, specifically focusing on how intermediaries display information

[3]See: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7777.

or alternative products and how these choices affect competition among firms, consumer surplus, and total welfare. For instance, platforms may provide informative details for particular products or position a favored product directly beneath the description of a similar product the consumer is browsing. These actions introduce unequal market treatment, influencing consumers' perceptions and purchasing decisions. This type of steering differs from traditional sponsorship methods because it does not involve payment from the sponsored company to the intermediary. Consequently, platforms may find recommending specific products and creating perceived market asymmetries advantageous, even without direct compensation. This chapter presents a model in which the intermediary can manipulate the relative differentiation between the two firms by simultaneously reducing the transportation cost for the prominent firm and increasing it for its rival by an equal amount, thereby maintaining the average transportation cost at a constant level.

The main result is that the asymmetric treatment can increase total industry profit and consumer surplus. The favored firm can considerably expand its reach as most consumers benefit from reduced transportation costs. However, the asymmetric treatment also enables the favored firm to raise its price, extracting more consumer surplus. In contrast, the rival firm is compelled to adopt a more aggressive pricing strategy to avoid a significant loss of demand. Consumers closer to the location of the less accessible firm benefit from the lowered price, although they incur larger transportation costs. The overall impact on consumers is positive and becomes more significant as the relative differentiation introduced by the intermediary increases. For the firms, the gains of the favored firm outweigh the losses incurred by the competitor. Nevertheless, if the intermediary monetizes the recommendation service, it can create distortions such that it captures the additional value generated in the market at the expense of consumers. The findings suggest that potential public interventions in the interests of consumers should focus more on the business model employed by the intermediary rather than solely aiming for a level playing field.

Chapter 3 examines the role of reputation systems in online marketplaces, focusing on online microtask platforms. These platforms serve as intermediaries connecting contractors and freelancers who often undertake repetitive and labor-intensive tasks. Examples of such platforms include Amazon Mechanical Turk (AMT) and TaskRabbit. Like other marketplaces,

online labor markets employ platform-specific reputation systems, prohibiting users from transferring their ratings to other platforms. Building an online reputation is costly, so platform-specific ratings can create lock-in effects, preventing users from switching to alternative platforms, even if they offer better economic conditions, such as lower fees. Different regulations, such as the GDPR in the European Union, the California Consumer Privacy Act, or the Chinese Personal Information Protection Law, have introduced the right to data portability, allowing users to request their data and transfer it to other online service providers. However, reputation data falls outside the scope of these policies since reviewers, and not the users, own the ratings and comments they generate.

This chapter aims to examine how users respond to the introduction and increase of fees and explore the motivations of online workers to switch platforms following the implementation of fees. Two policy regimes are analyzed: the status quo, where reputation transfer across platforms is not allowed, and an alternative regime, where reputation portability is enforced, enabling users to import their ratings when switching platforms. This study employs both theoretical and experimental methodologies. The theoretical analysis demonstrates that platforms can effectively lock users within their marketplace, enabling the platform to set higher fees than potential competitors without losing workers. Through an online lab-in-the-field experiment conducted with real online workers from AMT, the study analyzes how online workers respond to the introduction and increase of fees and how a reputation portability treatment can significantly increase the likelihood of switching platforms and improve online workers' working conditions. These findings suggest that reputation portability is essential in online markets where users rely on valuable ratings and recommend the imposition of reputation portability rules to mitigate lock-in effects.

1

Competition for Prominence

Co-authored with Leonardo Madio.

This paper examines the role of online intermediaries in influencing consumers' purchasing decisions by giving preferential treatment to certain retailers. We investigate the incentives of intermediaries to employ a "competition for prominence scheme", analyzing the impact on retailer strategies and consumer surplus. We show that, for a given fee, three alternative equilibria can emerge, two of which result in one retailer making no sale. We also find that intermediaries have a strategic interest in inducing intense competition between retailers by selecting one excluding equilibrium where double marginalization issues are mitigated and overall demand is maximized. We show that in equilibrium, the interests of the intermediary and the consumers are fully aligned. Finally, this scheme is always more profitable for the intermediary than auction-based alternatives as it replicates multiproduct monopolistic outcomes.

1.1 Introduction

The global landscape of online marketplaces has evolved to encompass a handful of dominant platforms that play a pivotal role in connecting sellers with consumers, significantly influencing their decisions and consumption patterns. Key mechanisms, such as recommender systems and the allocation of prominent positions to sellers, have emerged as powerful tools wielded by these platforms. A major example is given by Amazon— the largest marketplace in the world— which groups all listings associated with a specific product on a single webpage. Among the available retailers, the platform designates one as the default retailer, which appears prominently in the so-called "buy-box", whereas the other sellers are relegated to less prominent positions.[1] Obtaining the default position in online marketplaces has become vital for retailers, with as much as 80% of all Amazon transactions occurring through the buy-box. (U.S. House Judiciary Committee, 2020).

In this paper, we refer to this prominence allocation strategy as the "competition for prominence scheme". We delve into the dynamics and the implications of the competition for prominence scheme when implemented by online intermediaries, particularly examining its impact on retailers' competition and strategies as well as consumer surplus. While platforms often do not fully disclose their precise criteria for prominence allocation, they occasionally offer insights on how retailers can enhance their chances of obtaining this coveted position. For instance, Amazon seemingly prioritizes competitive prices, fast shipping, and excellent customer service, which can be considered as "quality" measures.[2]

We consider a model in which a monopoly platform connects consumers to two vertically differentiated retailers. We take inspiration from Amazon's approach and assume that the retailers offer the same product but differ in the "quality" of their ancillary services (e.g., next-day delivery or a more generous return policy), creating vertical differentiation from a consumer's perspective. We analyze the case in which one retailer provides a superior service compared to the other. For ease of exposition, we will refer to the retailer with the superior service as the high-quality retailer and its counterpart as the low-

[1] Comparable default prominence allocation schemes are now adopted by several other marketplaces, including Walmart in the United States, Otto in Germany, Fnac in France, and Bol.com in the Netherlands.

[2] For more details, see the *Amazon Seller Central Hub*.

quality retailer. For its intermediation service, the platform collects a per-unit fee for each realized sale. Consumers are of two types, actives and passives, and their willingness to pay for quality is heterogeneous. Active consumers always compare all offers and buy from the retailer that provides the highest utility. In contrast, passive consumers only consider the recommended offer and decide whether to buy it. The intermediary determines which retailer to show prominently based on the observed prices.

We show that the intermediary finds it optimal to assign a prominent position to the retailer with the lowest quality-adjusted price to boost consumer demand and the associated fees. Anticipating the allocation rule of the intermediary, retailers decide whether and how to compete for the prominent display. If the high-quality retailer is awarded prominence, the low-quality retailer fails to make any sales. Consequently, the low-quality retailer always has incentives to seek prominence for any given fee. On the other hand, the high-quality retailer is motivated to obtain prominence only if the share of passive consumers is sufficiently large. The rationale is that, due to vertical differentiation, the high-quality retailer naturally captures a portion of the active consumers, and reaching the passive consumers implies competing fiercely with the low-quality retailer. Facing the usual trade-off between volume and margins, the high-quality retailer can profitably give up prominence if the share of passive consumers is low and, instead, compete for prominence if the share of these consumers is large.

Depending on the high-quality retailer's incentives, three alternative equilibria exist for a given fee. If the share of passive consumers is large and the quality of the low-quality retailer is high enough, the high-quality retailer can give up the passive segment without losing much and let the low-quality retailer serve it, thereby relaxing competition. In this scenario, the low-quality retailer is an active competitor and, in equilibrium, there is a partially segmented market, softened competition, and both retailers earn positive profits. We refer to this outcome as the *market sharing equilibrium*.

Otherwise, when the share of passive consumers is small, or the quality gap between the two retailers is large enough, the high-quality retailer cannot afford to abandon the passive consumers. In these situations, we identify two alternative *excluding equilibria*, in which the low-quality retailer fails to make any sales. In the first excluding equilibrium, which occurs if the intermediary's commission fee is sufficiently low, the high-quality retailer becomes prominent by pricing aggressively, resulting in a low equilibrium price. In the second

excluding equilibrium, which arises if the commission fee of the intermediary is sufficiently high, the high-quality retailer can maintain prominence even by setting a monopoly price, as the low-quality retailer lacks the ability to compete effectively.

To determine which of the three equilibria is subgame perfect, we examine the incentives of the intermediary in setting the commission fee. The intermediary's interest lies in mitigating the double marginalization problem that arises when the two retailers compete by segmenting the market and softening competition. Additionally, it seeks to avoid the double marginalization problem that occurs when the high-quality retailer sets a monopoly price. Therefore, the intermediary finds it optimal to induce the first excluding equilibrium by allocating prominence to the high-quality retailer while stimulating a Bertrand-like competition that expands total consumer demand. This result shows that the interests of the intermediary are fully aligned with those of consumers. Remarkably, the competition for prominence strategy eliminates the double marginalization problem and yields market outcomes equivalent to a market structure in which a multiproduct monopolist directly sets prices for the two offers (and makes the high-quality product prominent).

We extend the model to consider the case in which two ex ante symmetric retailers have the option to directly acquire a quality upgrade (such as enhanced delivery services) from the intermediary for a fixed fee. This case resembles the service provided by Amazon known as the "Fulfilled by Amazon" program. Under this program, retailers can store their products in Amazon's warehouse and benefit from the marketplace's fast logistics network. This example provides a microfoundation for our baseline model, where vertical differentiation exists between retailers. We demonstrate that this extended scenario leads to the emergence of two symmetric equilibria characterized by asymmetric quality upgrades.

Finally, we compare the competition for prominence allocation scheme with an alternative auction-based prominence allocation scheme. In this scenario, the intermediary assigns prominence to the retailer bidding the highest fee. This case mirrors, for example, sponsorship programs made available by online marketplaces such as eBay, with its "Promoted Listings" where the highest bidder obtains the highest visibility. We show that an auction-based prominence allocation scheme, whereby the intermediary charges a per-unit fee and a fixed fee for assigning prominence, softens

competition and exacerbates double marginalization. While this scheme always makes both retailers sell products, their prices are excessively high and reduce demand. As a result, an intermediary always finds it optimal to assign prominence via a competitive scheme rather than via an auction. We also show that while competition for prominence benefits consumers because their demand is expanded due to lower final prices, total retailers' surplus may be lower under competition for prominence than under an auction-based allocation.

The paper is structured as follows. Section 1.2 reviews the literature on prominence allocation in online platforms and highlights our contributions. Section 1.3 presents the model and its key features. Section 1.4 analyzes the equilibrium allocation of prominence for both exogenous and endogenous commission fees. Section 1.5 presents two main extensions. Finally, Section 1.6 summarizes our findings and provides concluding remarks. Proofs are relegated to the Appendix.

1.2 Related Literature

This paper relates to the literature on intermediaries that, by organizing transactions on their marketplaces, decide whether and how they can make some sellers more prominent. A general finding in this literature is that prominence plays a critical role and affects both purchasing decisions and competition among rival sellers.

Armstrong et al. (2009) and Moraga-González et al. (2021) study a setting in which prominence is *exogenously* assigned by an intermediary to a seller and consumers have search costs. The authors abstract from the intermediary's interests and analyze the welfare effects of prominence. Armstrong et al. (2009) examine the effects of prominence in the context of sequential search, showing that the prominent seller sets a lower price and the non-prominent ones serve unsatisfied consumers with a higher price. They also find that, relative to the random search case, prominence maximizes industry profits but reduces consumer surplus, although prominence reduces the average search cost. In Moraga-González et al. (2021), consumers browse sellers' offers simultaneously. The authors find that prominence can increase consumer surplus even though the prominent seller increases its price by focusing on the least elastic segment of the market, thereby letting non-prominent sellers price aggressively to serve those consumers searching for an alternative. We differ from these studies

in that the intermediary endogenously allocates prominence as it grants more visibility in order to maximize its profits.

A more recent stream of the literature has focused on prominence allocation as a result of payments (e.g., auctions or direct payments) (Raskovich, 2007; Armstrong and Zhou, 2011; Inderst and Ottaviani, 2012; Teh and Wright, 2022; Krämer and Zierke, 2020; Bourreau and Gaudin, 2022; Long et al., 2022; Ciotti, 2023). Armstrong and Zhou (2011) show that, by granting prominence to the highest bidder, sellers' marginal costs are artificially increased, and so are the overall retail prices at the benefit of the intermediary.[3] In Inderst and Ottaviani (2012), the intermediary allocates prominence, balancing two tensions: the commission it receives from sellers and the reputation cost the intermediary incurs whenever it recommends a non-suitable product. Teh and Wright (2022), study a setting in which the intermediary's profits depend both on the margin sellers leave to obtain prominence and the commission they pay for each item sold. Thus, sellers compete both in prices and in commissions to obtain prominence. The authors find that steering harms both firms and consumers, and fiercer competition exacerbates price inflation due to the higher incentive of being recommended. Long et al. (2022) analyze how an intermediary can use the bidding system for sponsoring sellers to infer their private quality information and improve matching. Unlike this literature, the intermediary does not allocate prominence through auctions or direct payments in our setting. We show that it is in the interest of the intermediary to maximize the number of transactions by employing a non-monetary approach where prominence serves as a tool to foster competition among retailers.

Our analysis also relates to the search literature that deals with heterogeneous consumers. The population of active/passive consumers we study share some similarities with the taxonomy shoppers/captives introduced by Varian (1980). Mixed equilibria results generally arise in these studies because of the presence of captive consumers and sellers offering homogeneous products (Armstrong and Zhou, 2011; Ronayne and Taylor,

[3]In their setting, as in ours, there are two groups of consumers: informed ones, who costlessly compares sellers' offers, and uniformed ones, who only consider the offer of the default vendor. However, in our setting, prominence lowers retailers' prices. As the intermediary obtains a commission fee for each transaction, it is interested in allocating prominence to the retailers that lower prices and expand the total demand.

2022; Johnen and Ronayne, 2021; Armstrong and Vickers, 2022).[4] In our model, passives are not locked into a single firm as the captives. Instead, their consumption set is bounded by the recommendation of the intermediary. This difference plays an important role, as retailers do not have a fallback line if competition for the passive segment of the market is too intense. Therefore, when both retailers compete for prominence, the pricing strategies follow a downward Bertrand spiral, and retailers cannot profitably deviate by setting a higher price. As a result, the market dynamic we study leads to an equilibrium in pure strategy.[5,6]

The papers most closely related to our research are Dinerstein et al. (2018) and Bar-Isaac and Shelegia (2022). Dinerstein et al. (2018) study the welfare effects of a change in the eBay's platform design that made more prominent offers with lower prices. They show that narrowing the number of sellers shown to consumers makes price competition more intense, thereby leading to even lower prices. This mechanism resembles the Bertrand-like spiral that occurs when the intermediary, in our setting, can induce the first excluding equilibrium by choosing the fee. Unlike the authors, our analysis is more concerned about the interplay between retailers' pricing strategy and the intermediary's interest in a context in which obtaining a prominent allocation depends on the most profitable scenario for the intermediary.

Bar-Isaac and Shelegia (2022) also study the allocation of prominence by comparing an algorithm-based prominence design with an auction-based design. The first one resembles our competition for prominence scheme as retailers internalize how their prices impact the intermediary's profit and their visibility to consumers. Similarly to us, they show that this allocation scheme eliminates double marginalization and is more profitable than the auction design in various

[4] An exception is provided by Myatt and Ronayne (2023). The authors show the existence of pure strategy equilibrium in a sequential game where firms sell homogeneous products but have asymmetric marginal costs.

[5] Note that with a high marginal cost for the high-quality retailer, a mixed strategy equilibria might exist, as discussed in the Appendix.

[6] More broadly, our paper also relates to the stream of studies focusing on the problem of steering in the platform's also acting as retailers (de Cornière and Taylor, 2019; Anderson and Bedre-Defolie, 2021; Etro, 2021; Anderson and Bedre-Defolie, 2022; Hagiu et al., 2022; Zennyo, 2022), how platforms govern their ecosystem (Teh, 2022), as well as how they influence intra-platform competition (Casner, 2020; Karle et al., 2020; Jeon et al., 2022). In our analysis, we abstract away from the issue of self-preferencing, which has been studied extensively in recent years (Chen and Tsai, 2023; Lee and Musolff, 2021; Cure et al., 2022; Hunold et al., 2022).

cases. In their analysis, markets are covered, and passives and actives never coexist in a single market. Accounting for the presence of the two groups of consumers and the possibility for the market not to be fully covered is key in our analysis because it allows us to analyze real-world market dynamics when the intermediary employs a competition for prominence scheme. Indeed, our approach is consistent with evidence from marketplaces such as Amazon, where a prominent allocation ensures exclusive access to a portion of consumers to the retailer that satisfies some criteria. In this scenario, retailers face the trade-off of setting a higher price in the active segment or lowering the price to win prominence and secure the passive one. Finally, in an extension, we also compare the two steering methods and show that the intermediary never prefers an auction-based prominence allocation approach.

1.3 Model Setup

We consider a market in which two retailers sell a product via a monopolist intermediary and pay a fixed and symmetric per-unit commission fee w to the latter.[7] We assume that retailers are differentiated in the (exogenous) quality of their ancillary services. For instance, one retailer provides a better customer experience than the other (e.g., a generous return policy or faster delivery). For ease of exposition, throughout the paper we refer to the retailer with the superior service as the high-quality retailer and the retailer with the inferior service as the low-quality retailer. Moreover, with a slight abuse of notation, we often refer to them as H and L, respectively, and the associated quality is q_H and q_L, with $0 < q_L < q_H$.

In our analysis, we also assume that the difference in the quality of the ancillary services of the two retailers is not too high, i.e., $q_L > q_H/2$. This assumption ensures that the low-quality retailer is a potential competitor of the high-quality retailer. In other words, the assumption ensures that the market is contestable and there is enough room for both qualities.[8] We assume that H and L have identical marginal production and service costs, which are

[7] We discuss asymmetric commission fees at the end of Section 1.4.2.

[8] Relaxing this assumption would make the low-quality retailer unable to compete with the high-quality one, thereby creating a blockaded entry. We abstract from this less interesting case in our analysis by assuming $q_L > q_H/2$.

normalized to 0.[9]

We consider a market in which consumers can only purchase products through the intermediary and have varying preferences for increases in quality, represented by a parameter $\theta \in [\underline{\theta}, \overline{\theta}]$ that is uniformly distributed in the range $[0, 1]$. Consumers have unit demand and their population is divided into two segments: *active* consumers who account for a share $\lambda \in (0, 1)$ of the total population and have access to all product listings, and *passive* consumers who account for the remaining share $1 - \lambda$ and only consider the product that the intermediary prominently displays.[10] We assume θ to be independently and identically distributed across both segments of consumers.

An active consumer who buys a product from retailer $i = \{L, H\}$ at price p_i obtains the following utility:

$$U_i^{\lambda}(p_i) = \theta q_i - p_i \qquad \forall i = H, L,$$

whereas a passive consumer who buys a product from the prominent retailer obtains:

$$U^{1-\lambda}(p) = \theta q - p,$$

where q and p represent, respectively, the quality and the price of the prominent retailer identified by the intermediary, i.e., $p = p_L$ and $q = q_L$ if the low-quality retailer is prominent, otherwise $p = p_H$ and $q = q_H$. We assume that the utility of a consumer who does not buy any product is normalized to zero.

The intermediary imposes a fixed commission fee w on retailers for every transaction that occurs. We denote as $D_i^{\lambda}(p_i, p_j, w)$ the demand of a retailer i from the active consumers and as $D_H^{1-\lambda}(p_H)$ (resp. $D_L^{1-\lambda}(p_L)$) the demand of the high-quality (resp. low-quality) retailer from passive consumers if made prominent. If the high-quality retailer is prominently displayed, the profits of

[9] In the Appendix, we allow for the possibility that the high-quality retailer faces a higher marginal service cost due, e.g., to logistics and the implementation of the return policy. In this case, we discuss that our results hold qualitatively if the difference in the marginal costs of the two retailers is sufficiently small. Otherwise, similar to Varian-like models, mixed strategies arise. Specifically, if the difference in the marginal costs is large enough, the low-quality retailer can always undercut the price of the high-quality rival to gain prominence until it induces the high-quality retailer to "retreat" by increasing its price and serving only the active consumers.

[10] This segmentation can be motivated by assuming that active consumers have a low cost of searching and compare all product listings before making a purchase decision, whereas passive consumers have a higher search cost and are more likely to rely on the prominent offer.

the high- and low-quality retailers are given by:

$$\pi_H^H(p_H, p_L, w) = \Big[\lambda D_H^\lambda(p_H, p_L) + (1-\lambda) D_H^{1-\lambda}(p_H)\Big](p_H - w),$$
$$\pi_L^H(p_L, p_H, w) = \Big[\lambda D_L^\lambda(p_L, p_H)\Big](p_L - w),$$

and the profit of the intermediary is:

$$\Pi^H(p_H, p_L, w) = w\Big[\lambda\Big(D_H^\lambda(p_H, p_L) + D_L^\lambda(p_L, p_H)\Big) + (1-\lambda) D_H^{1-\lambda}(p_H)\Big].$$

If the low-quality retailer is prominently displayed instead, the profits of the high- and low-quality retailers are given by:

$$\pi_H^L(p_H, p_L, w) = \Big[\lambda D_H^\lambda(p_H, p_L)\Big](p_H - w),$$
$$\pi_L^L(p_L, p_H, w) = \Big[\lambda D_L^\lambda(p_L, p_H) + (1-\lambda) D_L^{1-\lambda}(p_L)\Big](p_L - w),$$

and the profit of the intermediary is:

$$\Pi^L(p_H, p_L, w) = w\Big[\lambda\Big(D_H^\lambda(p_H, p_L) + D_L^\lambda(p_L, p_H)\Big) + (1-\lambda) D_L^{1-\lambda}(p_L)\Big].$$

The timing of the game is as follows. In the first stage, the intermediary sets the commission fee w. In the second stage, retailers compete by setting prices p_H and p_L, respectively. In the third stage, the intermediary allocates prominence to the retailer that maximizes its total profit. In the final stage, active consumers compare the offers of the two retailers and decide whether to buy and from which retailer, whereas passive consumers decide whether to buy from the prominent retailer. Our solution concept is subgame perfect Nash equilibrium.

1.4 Analysis

In this section, we present the analysis of the baseline model. First, we solve the model for a given commission fee w and study the best replies of the two retailers. Second, we endogenize the commission fee and solve the first stage of the game.

1.4.1 Analysis for a given commission fee

We start by analyzing the consumer's decision in the last stage of the game. An active consumer type-θ buys from retailer i if, and only if, $U_i^\lambda(p_i) \geq$

$\max\{U^{\lambda}_{-i}(p_{-i}), 0\}$. We denote as $\overline{\theta}(p_L, p_H)$ the consumer who is indifferent between buying from the high- or the low-quality retailer, i.e., $\overline{\theta}(p_L, p_H)q_H - p_H = \overline{\theta}(p_L, p_H)q_L - p_L$. Similarly, we denote as $\underline{\theta}(p_L, p_H)$ the consumer who is indifferent between buying from the low-quality retailer or not buying, i.e., $\underline{\theta}(p_L, p_H)q_L - p_L = 0$. Note that for $q_L/p_L > q_H/p_H$, all consumers of type $\overline{\theta} > \theta > \underline{\theta}$ buy from the low-quality retailer, whereas all consumers of type $\theta > \overline{\theta}$ buy from the high-quality retailer. The masses of active consumers buying from the two retailers are:

$$\begin{aligned} D^{\lambda}_L(p_L, p_H) &= \max\left\{0, \frac{p_H - p_L}{q_H - q_L} - \frac{p_L}{q_L}\right\}, \\ D^{\lambda}_H(p_H, p_L) &= \min\left\{1 - \frac{p_H - p_L}{q_H - q_L}, 1 - \frac{p_H}{q_H}\right\}. \end{aligned} \tag{1.1}$$

Note that, for $q_L/p_L < q_H/p_H$, the marginal consumer is indifferent between buying from H and not buying.

A passive consumer type-θ buys from retailer i if, and only if, $U^{\lambda}(p) \geq 0$. Therefore, the mass of passive consumers that buy from the prominent retailer is either:

$$D^{1-\lambda}_L(p_L) = 1 - \frac{p_L}{q_L}, \quad \text{or} \qquad D^{1-\lambda}_H(p_H) = 1 - \frac{p_H}{q_H}, \tag{1.2}$$

depending on whether the low-quality retailer or the high-quality retailer is shown prominently.

In the third stage, the intermediary allocates prominence to the retailer that, conditional on receiving a prominent display, maximizes the profit for the intermediary. Since we consider a per-unit fee, this is equivalent to maximizing the number of transactions and, therefore, the consumer demand. As a tie-breaking rule, we assume that, in any case of indifference in assigning prominence to either retailer, the intermediary assigns it to the high-quality retailer.

To derive the prominence allocation rule, we first determine the demands of the two retailers in each market segment. Let us first consider the active segment. If $p_H/q_H > p_L/q_L$, then $(p_H - p_L)/(q_H - q_L) > p_L/q_L$ and, therefore, demands are given by:

$$D^{\lambda}_L(p_L, p_H) = \frac{p_H - p_L}{q_H - q_L} - \frac{p_L}{q_L}, \qquad D^{\lambda}_H(p_H, p_L) = 1 - \frac{p_H - p_L}{q_H - q_L}.$$

Otherwise, if $p_H/q_H \leq p_L/q_L$, then $(p_H - p_L)/(q_H - q_L) \leq p_L/q_L$ and, therefore,

the demands are given by:

$$D_L^{\lambda}(p_L, p_H) = 0, \qquad D_H^{\lambda}(p_H, p_L) = 1 - \frac{p_H}{q_H}.$$

Let us consider now the passive segment. If H is prominent, demands are given by:

$$D_L^{1-\lambda}(p_L, p_H) = 0, \qquad D_H^{1-\lambda}(p_H, p_L) = 1 - \frac{p_H}{q_H}.$$

On the contrary, if L is prominent, demands are given by:

$$D_L^{1-\lambda}(p_L, p_H) = 1 - \frac{p_L}{q_L}, \qquad D_H^{1-\lambda}(p_H, p_L) = 0.$$

We can now examine the profit function of the intermediary in each scenario. If $p_H/q_H > p_L/q_L$, the intermediary obtains the following profits by assigning prominence to L and H, respectively:

$$\Pi^L(p_H, p_L, w) = \Big(1 - \frac{p_L}{q_L}\Big)w,$$
$$\Pi^H(p_H, p_L, w) = \lambda\Big(1 - \frac{p_L}{q_L}\Big)w + (1-\lambda)\Big(1 - \frac{p_H}{q_H}\Big)w.$$

and prominence is awarded to L if:

$$\begin{aligned}\Pi^H(p_H, p_L, w) - \Pi^L(p_H, p_L, w) &= \lambda\Big(1 - \frac{p_L}{q_L}\Big)w + (1-\lambda)\Big(1 - \frac{p_H}{q_H}\Big)w - \Big(1 - \frac{p_L}{q_L}\Big)w \\ &= w(1-\lambda)\Big(\frac{p_L}{q_L} - \frac{p_H}{q_H}\Big) < 0.\end{aligned}$$

If $p_H/q_H \leq p_L/q_L$, the intermediary obtains the following profits by assigning prominence to L and H, respectively:

$$\Pi^L(p_H, p_L, w) = \lambda\Big(1 - \frac{p_H}{q_H}\Big)w + (1-\lambda)\Big(1 - \frac{p_L}{q_L}\Big)w,$$
$$\Pi^H(p_H, p_L, w) = \Big(1 - \frac{p_H}{q_H}\Big)w.$$

and prominence is awarded to H if:

$$\begin{aligned}\Pi^H(p_H, p_L, w) - \Pi^L(p_H, p_L, w) &= \Big(1 - \frac{p_H}{q_H}\Big)w - \Big[\lambda\Big(1 - \frac{p_H}{q_H}\Big)w + (1-\lambda)\Big(1 - \frac{p_L}{q_L}\Big)w\Big] \\ &= w(1-\lambda)\Big(\frac{p_L}{q_L} - \frac{p_H}{q_H}\Big) \geq 0.\end{aligned}$$

Simplifying the above expressions, the following lemma presents the conditions for which prominence is assigned to the high-quality or low-quality retailer.

Lemma 1. *The intermediary assigns prominence to the high-quality (resp. low-quality) retailer if:*

$$\frac{p_H}{q_H} \leq (>) \frac{p_L}{q_L}. \tag{1.3}$$

Lemma 1 means that the retailer with the lowest quality-adjusted price is granted prominence. Therefore, if the high-quality retailer wants to be prominent, it must match the quality-adjusted price of its low-quality competitor. One important implication of this lemma is that the competition for prominence scheme leads to more competition in the market, as it induces retailers to lower their prices, for a given unit fee, in order to be granted prominence.[11]

One implication of Lemma 1 is that, as we have already shown, the high-quality retailer can eliminate its competitor from the market by setting its price to $p_H = p_L q_H / q_L$. In other words, evaluating the demand of the low-quality retailer at this price, we observe that $D_L^{\lambda}(p_L, p_H) = 0$, for any $p_L \geq w$. On the contrary, the low-quality retailer can never exclude its competitor. This is a direct result of the vertical differentiation between the two retailers.

Lemma 2. *If the high-quality retailer is prominent, the low-quality retailer makes no sales (excluding equilibrium). If the low-quality retailer is prominent, both retailers make sales (market sharing equilibrium).*

To define the retailers' pricing strategies and identify the emerging equilibrium(a), we determine the retailers' best replies in the second stage of the game.

Retailers anticipate the allocation of prominence made by the intermediary and compete in prices. As shown in Lemma 2, if the high-quality retailer is prominent, the low-quality retailer makes no sales. Therefore, conditional on the high-quality retailer setting a price that makes it prominent, the low-quality retailer always has the incentive to undercut the quality-adjusted price of its rival. This undercutting strategy can be blocked in two scenarios. Firstly, if

[11] Note that considering a different commission fee, such as an ad-valorem fee, would imply a different prominence allocation rule, and significantly different retailers' strategies. Specifically, the intermediary would account for the profits on its intensive and extensive margins from both retailers. On the other hand, retailers willing to obtain prominence would need to set prices close to the monopoly level. However, this price choice would allow the rival to easily capture the active segment by undercutting the quality-adjusted price of the prominent firm. Depending on the quality difference and the size of the active segment, the prominent retailer may not be willing to let the active consumers go. Therefore, this would create a setting similar to Varian (1980), in which equilibria in pure strategies fail to exist.

L reaches its price floor, equal to the commission fee, and H finds it optimal to become prominent. Secondly, if H finds it optimal not to serve the passive consumers, thereby focusing only on the active ones, the market will reach a market sharing equilibrium.

In what follows, we report and discuss the best-responses of the two retailers. For ease of exposition, we use $\hat{p}_H$, $\hat{p}_L$ and $\tilde{p}_L$ (which are defined in the Appendix), where $\tilde{p}_L > \hat{p}_L > w$, to separate the regions in which the various segments of the best-reply function apply given the prominence allocation rule. The best reply of the low-quality retailer is:

$$p_L(p_H) = \begin{cases} \frac{\lambda q_L(p_H+w-(q_H-q_L))+(q_H-q_L)(q_L+w)}{2(q_H-(1-\lambda)q_L)}, & \text{if } p_H \geq \hat{p}_H, \\ p_H \frac{q_L}{q_H} - \varepsilon, & \text{if } w\frac{q_L}{q_H} < p_H < \hat{p}_H, \\ w, & \text{if } p_H \leq w\frac{q_H}{q_L}. \end{cases} \quad (1.4)$$

Specifically, the high-quality retailer loses prominence if its price is sufficiently high, i.e., $p_H \geq \hat{p}_H$. Therefore, the price set by the low-quality retailer ensures market sharing, i.e., it is equal to the one identified in the first line of (1.4). On the other hand, if the price set by the high-quality retailer is intermediate, i.e., $w\frac{q_L}{q_H} < p_H < \hat{p}_H$, the low-quality retailer can obtain prominence only by undercutting the high-quality retailer by an $\varepsilon \to 0$, resulting in the following best reply: $p_L(p_H) = p_H q_L/q_H - \varepsilon$. Finally, suppose the price of the high-quality retailer is sufficiently low, i.e., $p_H \leq wq_H/q_L$. In that case, it is not possible for the low-quality retailer to undercut the rival and become prominent while making a profit. In the latter case, the best this retailer can do is to set a price equal to its marginal cost — the fee set by the intermediary w — and get zero profit.

The best reply of the high-quality retailer is:

$$p_H(p_L) = \begin{cases} \frac{1}{2}(p_L + q_H - q_L + w), & \text{if } p_L < \tilde{p}_L, \\ p_L \frac{q_H}{q_L}, & \text{if } \tilde{p}_L \leq p_L < \hat{p}_L, \\ \frac{q_H+w}{2}, & \text{if } p_L \geq \hat{p}_L. \end{cases} \quad (1.5)$$

If the price set by its low-quality rival is sufficiently low, i.e., less than $\tilde{p}_L$, the high-quality retailer gives up on prominence, and a market sharing outcome can emerge with the high-quality retailer setting $p_H = (1/2)(p_L + q_H - q_L + w)$. If the low-quality retailer sets an intermediate price, the high-quality retailer can obtain prominence by just matching the rival's quality-adjusted price, i.e., $p_H(p_L) = p_L q_H/q_L$ (and actually finds it optimal to do so). Finally, if the price

of the low-quality retailer is high enough, the high-quality retailer can secure prominence by setting the unconstrained monopoly price $p_H = (q_H + w)/2$.

Both best replies are continuous, piecewise linear, and upward-sloping, meaning they do not have the "down the stairs/up the elevator" characteristics typical of Varian-like models. The reason is that passive consumers in our model are not the same as Varian's "captive" consumers. Specifically, they are not ex ante captive to any retailer but become captive to the prominent retailer because of the intermediary's prominence rule. Moreover, unlike in Varian (1980), retailers never have incentives to increase their price for any given price of the other retailer. Specifically, both retailers face the same threshold for cornering the market of active consumers and getting prominence, which implies capturing also the market for passive consumers. This means that retailers must undercut the rival to get both types of consumers. The absence of a safety net provided by the exploitation of captive consumers does not induce firms to "overcut" the rival. Consequently, there is no upward jump in the best replies of the two retailers.

In the Appendix, we show that the market sharing equilibrium can be sustained with the following prices only under some circumstances. Formally,

$$\begin{aligned} p_L(w) &= \frac{\lambda q_L(3w - q_H + q_L) + 2(q_H - q_L)(q_L + w)}{4q_H - (4 - 3\lambda)q_L}, \\ p_H(w) &= \frac{2q_H^2 - (3 - \lambda)q_H q_L + 3q_H w + (1 - \lambda)q_L(q_L - 3w)}{4q_H - (4 - 3\lambda)q_L}. \end{aligned} \tag{1.6}$$

under the conditions that $p_L < \tilde{p}_L$ and $p_H \geq \hat{p}_H$ (first line in Equation 1.4). This equilibrium is possible if and only if the following two conditions jointly hold:

$$(a) \quad w < \frac{q_L}{2}, \qquad (b) \quad \tilde{\lambda} \equiv \frac{2q_H w + q_L^2 - 3q_L w}{q_H q_L + q_L^2 - 3q_L w} < \lambda < 1. \tag{1.7}$$

In other words, when the share of active consumers is significant (represented by $\lambda > \tilde{\lambda}$), the size of the passive segment is small, and the value attached to obtaining prominence becomes relatively low for both retailers. In this situation, the high-quality retailer is less motivated to aggressively compete for prominence as it can still achieve substantial profits by allowing its competitor to cater to the passive segment. As a result, the low-quality retailer serves the passive segment and part of the active one, whereas the high-quality retailer only serves the (large) active segment. This condition leads to a market sharing equilibrium, where retailers coexist.

Figure 1.1 illustrates the existence of a market sharing equilibrium for a given w in the case in which $\lambda > \tilde{\lambda}$ and $w < q_L/2$. In this scenario, the equilibrium results from the intersection of the blue line — the best reply of the low-quality retailer — and the orange line — the best reply of the high-quality retailer.

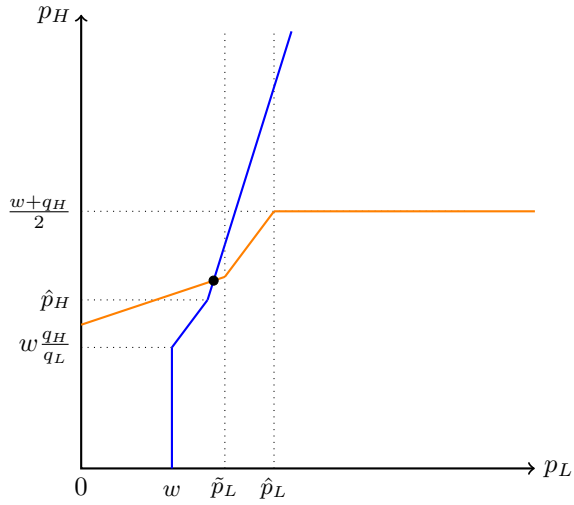


Figure 1.1. Market sharing equilibrium ($w = \frac{1}{5}$, $q_L = \frac{3}{4}$, $q_H = \frac{3}{2}$, $\lambda = \frac{5}{7} > \tilde{\lambda} = \frac{19}{33}$).

If the conditions in (1.7) are not satisfied, the high-quality retailer is prominent, and the low-quality retailer is excluded from the market. In this situation, two possible alternative equilibria can arise. The first equilibrium arises because of the Bertrand-like downward spiral of prices (illustrated in Figure 1.2). This equilibrium involves the high-quality retailer setting a very low price, precisely $p_H = wq_H/q_L$, to match the low-quality retailer's quality-price ratio to retain the prominent position and attract all the active consumers. The second equilibrium(illustrated in Figure 1.3) involves the high-quality retailer setting a monopoly price, as indicated in the third line of Equation (1.5). In the Appendix, we show that the first equilibrium emerges when the price of the low-quality retailer is still relatively low, which, in turn, is the case if the commission fee w is sufficiently small, i.e., $w \leq (q_H q_L)/(2q_H - q_L)$. The excluding equilibrium prices in this scenario are $p_H = wq_L/q_L$ and $p_L = w$, respectively. The second equilibrium emerges instead when the fee is sufficiently large, which leads to a higher price for the

low-quality retailer. In this case, the excluding equilibrium prices are $p_H = (q_H + w)/2$ and $p_L = w$, respectively.

Figures 1.2 and 1.3 illustrate the existence of the two types of excluding equilibria. As explained earlier, a necessary condition for any of these two equilibria to be observed is $w > q_L/2$ For relatively low values of w (Figure 1.2), the excluding equilibrium is given by the intersection of the two best replies, which occurs as a consequence of a Bertrand downward spiral of prices. For relatively high values of w (Figure 1.3), instead, the excluding equilibrium is given by the crossing of the two best replies, and it occurs with the high-quality retailer setting a monopoly price. We summarize this discussion in the following proposition.

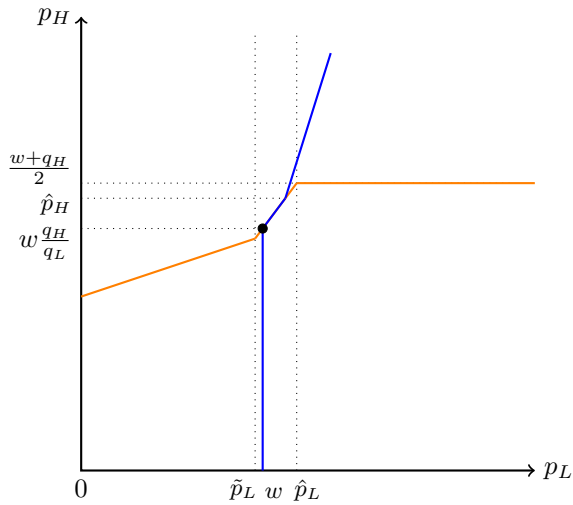


Figure 1.2. Excluding equilibrium with a low w ($w = \frac{2}{5}$, $q_L = \frac{3}{4}$, $q_H = \frac{3}{2}$, $\lambda = \frac{5}{7}$).

Proposition 1. *If $w < q_L/2$ and $\lambda > \tilde{\lambda}$, there exists a unique equilibrium in which the low-quality retailer is prominent whereas the high-quality retailer serves part of the active consumers ("market sharing equilibrium"); prices are given by (1.6). Otherwise, there is a unique equilibrium ("excluding equilibrium") such that the high-quality retailer is prominent and serves all consumers with a price of $p_H = wq_L/q_L$ if $q_L/2 \leq w \leq (q_H q_L)/(2q_H - q_L)$ or with a price of $p_H = (q_H + w)/2$ if $w > (q_H q_L)/(2q_H - q_L)$, whereas the low-quality retailer sets $p_L = w$.*

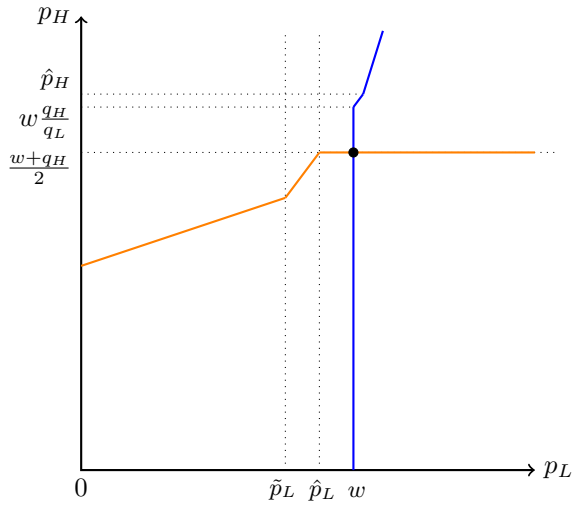


Figure 1.3. Excluding equilibrium with a high w ($w = \frac{3}{5}$, $q_L = \frac{3}{4}$, $q_H = \frac{3}{2}$, $\lambda = \frac{5}{7}$).

Figure 1.4 provides a graphical summary of Proposition 1. It shows the equilibrium outcomes as a function of the size of the active segment, λ (on the y-axis), and the exogenous commission fee w (on the x-axis). The dark blue area represents the parameter constellation in which a market sharing equilibrium occurs. In contrast, the mild blue and the light blue areas represent those areas in which the first and the second excluding equilibria arise, respectively. The orange line represents the function of $\tilde{\lambda}$ for a given w.

Note that these results hold for any given commission fee, which can rationalize scenarios in which fees are a long-run commitment of the platform and, therefore, not adjusted depending on each product type. Alternatively, one can think about a marketplace with multiple product categories and homogeneous commission fees across categories. In this scenario, the intermediary is limited in adjusting the fee depending on the competition for a given product.

1.4.2 Endogenous commission fee

So far, we have considered the retailers' strategies for a given commission fee. We introduce the first stage of the game and analyze the optimal commission fee for the intermediary.

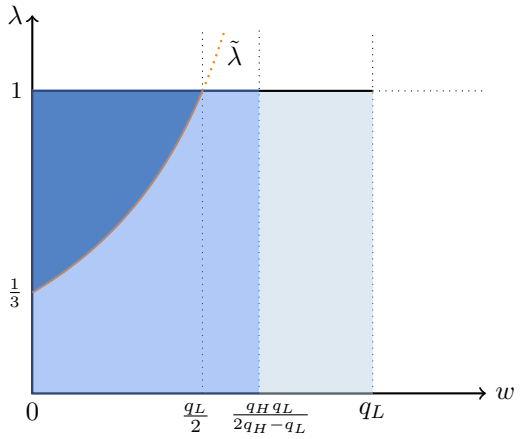


Figure 1.4. Summary of the equilibria as a function of λ and w ($q_L = \frac{3}{4}$, $q_H = \frac{3}{2}$).

First, we note that, in the market sharing equilibrium, the intermediary is constrained in the choice of its fee, which should be less than $q_L/2$. Since this constraint binds, the maximum fee the intermediary can set in this scenario is $w = q_L/2 - \varepsilon$, where $\varepsilon \to 0$. With a slight abuse of notation, we now refer to $\Pi^L(\cdot)$ as the profit associated with the fee $w = q_L/2 - \varepsilon$, i.e.,

$$\Pi^L(\cdot) \approx \frac{q_L(2(\lambda+1)q_H - (2-\lambda)q_L)}{4(4q_H - (4-3\lambda)q_L)}.$$

Second, in the first excluding equilibrium, the optimal fee is $w = q_L/2$, and, with the slight abuse of notation, the associated equilibrium profit of the intermediary is denoted $\Pi^{H1}(\cdot) = q_L/4$. We find that, the first excluding equilibrium — where the fee is set unconstrained — is always more profitable for the intermediary than the market sharing equilibrium — where the fee is set under the binding constraint, i.e., $\Pi^{H1}(\cdot) > \Pi^L(\cdot)$. This implies that the intermediary will never induce a market sharing equilibrium.

Finally, in the second excluding equilibrium, the optimal fee is $w = \max\{q_H/2, q_H q_L/(2q_H - q_L)\}$ where $\varepsilon \to 0$ depending on whether the constraint on w that guarantees existence of this equilibrium binds or is slack. With abuse of notation, the associated equilibrium profit of the intermediary when the constraint is slack is $\Pi^{H2}(\cdot) = q_H/8$, which occurs if $q_H \geq 3q_L/2$, whereas the associated profit when the constraint binds is $\Pi^{\overline{H2}}(\cdot) \approx (q_H q_L(q_H - q_L))/(q_L - 2q_H)^2$, which occurs if $q_H < 3q_L/2$. In the latter case the intermediary is constrained in setting a fee equal to

$w = q_H q_L/(2q_H - q_L) + \varepsilon$. Regardless of the fee set by the intermediary in this scenario, we observe that both profits are always lower than the profit obtained by the intermediary in the first excluding equilibrium.[12] As a result, the second excluding equilibrium is never selected by the intermediary.

Overall, the intermediary always finds it optimal to induce the first excluding equilibrium in which the high-quality retailer competes fiercely for prominence, and the low-quality retailer cannot make any sales. We summarize this result in the following proposition.

Proposition 2. *Under the maintained assumption that $q_L > q_H/2$, the equilibrium pair of prices $(p_L, p_H) = (w, wq_H/q_L)$ is subgame perfect. In equilibrium, the intermediary imposes a fee equal to $w = q_L/2$, which induces the high-quality to set a price equal to $p_H = wq_H/q_L$, gain prominence, and consequently, serve the entire market.*

Proposition 2 shows that, in equilibrium, the intermediary always finds it optimal to trigger an intense competition between the two retailers, thereby inducing a Bertrand-like spiral. This approach mitigates the double marginalization problem that would otherwise arise in the second excluding equilibrium.

This finding depends on the assumption that $q_L > q_H/2$, which ensures that the low-quality retailer can compete fiercely in the market. Note that this condition results from the fact that $q_L \geq w$, where w represents the highest fee set by the intermediary ($w^{H2} = q_H/2$). This condition holds if and only if $q_L > q_H/2$. Notably, failure to meet this condition would lead to a significant quality differential between the two retailers, prompting the intermediary to have an ex ante incentive to exclude the low-quality retailer by inducing the second excluding equilibrium. In such a scenario, the market structure would generate a blockaded entry and resemble a classic vertical chain, exacerbating the double marginalization problem. It is important to notice that this outcome would be equivalent to one in which the intermediary excludes the low-quality retailer, for example, as a result of an initial screening. In such a case, no competition for prominence would take place.

In equilibrium, therefore, the profit of the intermediary and of the retailers are;

$$\Pi^{H1}(\cdot) = \frac{q_L}{4}, \qquad \pi_H^{H1}(\cdot) = \frac{q_H - q_L}{4}, \qquad \pi_L^{H1}(\cdot) = 0, \tag{1.8}$$

[12] Note that $\Pi^{H2}(\cdot) \equiv q_H/8 < q_L/4 \equiv \Pi^{H1}(\cdot)$ because $q_L > q_H/2$ by assumption, and $\Pi^{\overline{H2}}(\cdot) \equiv (q_H q_L(q_H - q_L))/(q_L - 2q_H)^2 < q_L/4 \equiv \Pi^{H1}(\cdot)$ for any $q_H > q_L$.

whereas consumer surplus, denoted as $CS^{H1}(\cdot)$, and social welfare, denoted as $W^{H1}(\cdot)$, are:

$$CS^{H1}(\cdot) = \frac{1}{8}q_H, \qquad W^{H1}(\cdot) = \frac{3}{8}q_H. \tag{1.9}$$

It is important to note that the equilibrium selection induced by the intermediary also benefits consumers. This is because the interests of the intermediary are inherently aligned with those of the consumers, as the former maximizes its profit when the total demand is maximized. In essence, the market sharing equilibrium leads to sub-optimal outcomes for consumers, as it fails to fully exploit competitive pricing and the benefits of differentiation between retailers. On the other hand, the second excluding equilibrium, both when constrained and unconstrained, results in higher prices, which is detrimental to consumers. Therefore, the first excluding equilibrium — selected by the intermediary in the first instance — enhances market efficiency and lower prices, leading to the most favorable scenario for consumers among those that can possibly arise.

Corollary 1. *In equilibrium, the scenario selected by the intermediary is also the most favorable to consumers.*

Furthermore, it is worth highlighting that the intermediary, through its strategic selection of the equilibrium via the choice of the fee, achieves identical total industry profit, consumer surplus, and welfare to that of a multiproduct monopolist — a hypothetical entity controlling the entire distribution and pricing of products. To understand why, consider the following game in which a monopolist sells both high and low-quality offers. Since the intermediary also distributes its product, no commission fee is paid, meaning that $w = 0$. In the first stage of the game, the monopolist sets prices for both offers and chooses which one to display prominently, whereas in the second stage, consumers make their purchasing decisions.

The multiproduct monopolist has the following profit function if its low-quality offer is prominent:

$$\Pi^M(p_H, p_L) \equiv \lambda\Big(1 - \frac{p_H - p_L}{q_H - q_L}\Big)p_H + \Big[\lambda\Big(\frac{p_H - p_L}{q_H - q_L} - \frac{p_L}{q_L}\Big) + (1-\lambda)\Big(1 - \frac{p_L}{q_L}\Big)\Big]p_L,$$

and the following profit function if its high-quality offer is prominent:

$$\Pi^M(p_L, p_H) \equiv \Big[\lambda\Big(1 - \frac{p_H - p_L}{q_H - q_L}\Big) + (1-\lambda)\Big(1 - \frac{p_H}{q_H}\Big)\Big]p_H + \lambda\Big(\frac{p_H - p_L}{q_H - q_L} - \frac{p_L}{q_L}\Big)p_L.$$

Regardless of which offer is made prominent, the multiproduct monopolist would choose the following pair of monopoly prices for the two products $(p_H^M, p_L^M) = (q_H/2, q_L/2)$. Intuitively, given prices, the monopolist would maximize total demand by assigning prominence to its high-quality offer. As in the baseline model, this pair of prices would crowd out demand for the low-quality retailer.[13] Interestingly, the profit of the intermediary at equilibrium is equal to the total industry profit of the baseline model (i.e., $\Pi^{H1}(\cdot) + \pi_H^{H1}(\cdot)$):

$$\Pi^M(p_H^M, p_L^M) = \frac{q_H}{4}.$$

Consumer surplus and welfare are given by:

$$CS^M(p_H^M, p_L^M) = \frac{q_H}{8}, \qquad W^M(p_H^M, p_L^M) = \frac{3}{8}q_H, \tag{1.10}$$

which are identical to (1.9). We can conclude the following.

Proposition 3. *The market outcome of a multiproduct monopolist is equivalent to the one emerging in equilibrium under competition for prominence.*

This proposition shows that the intermediary can still influence the prices set by the retailers in a way that replicates the behavior of a multiproduct monopolist despite lacking direct control over the strategies of the two retailers. Yet, the intermediary does not extract the entire surplus from the high-quality retailer, which could be possible only via price discrimination strategies. One possibility is to allow retailers that are ex ante symmetric to become asymmetric in their quality via ancillary services and extract the remaining surplus of the high-quality retailer via a fixed fee. We discuss this possibility in the next section. Alternatively, the intermediary may set two different per-unit fees, i.e., w_L and w_H. These fees would induce the intermediary to always prefer the first excluding equilibrium and obtain monopoly profits by setting $w_L = q_L/2$ and $w_H = q_H/2$. This practice, however, would ring the bells of antitrust authorities. The unjustified discriminatory treatments among retailers would violate art. 102 of the Treaty of Functioning of the European Union.

[13] Note that the presence of high- and low-quality offers does not imply quality discrimination among consumers with different tastes for quality, as at equilibrium, none of them finds it optimal to purchase the low-quality offer. This is in contrast to the model by Mussa and Rosen (1978).

1.5 Extensions

In this section, we explore two extensions of our model. Firstly, we consider a scenario where retailers are initially homogeneous, offering identical products and retailing services, but can upgrade their quality by purchasing ancillary services from the intermediary. Secondly, we present an alternative prominence allocation scheme for the intermediary, wherein retailers have the option to purchase prominence.

1.5.1 Endogenous asymmetric quality

One way to microfound asymmetric quality between retailers is by considering that the intermediary offers ancillary services. This is common in many online marketplaces, where ancillary services are offered to enhance the consumer experience. These services may include improved logistics and fulfillment, enrollment in generous return policies, or access to round-the-clock customer service. For instance, in the case of Amazon, retailers can choose to enroll in the Fulfillment by Amazon (FBA) program by paying a fee or, alternatively, use their logistics independently (Fulfillment by Merchants).

In our modified setting, retailers are initially homogeneous with quality q_L. However, they can purchase a quality upgrade from the intermediary at a fixed fee of $F > 0$, which elevates their quality to q_H. In the first stage, the intermediary determines the fixed upgrading fee F and the commission fee w. In the second stage, retailers independently decide whether to purchase the quality upgrade from the intermediary. Then, in the third stage, retailers simultaneously set their prices, and finally, the intermediary allocates prominence to a retailer based on the established prominence allocation rule.

The following cases can now emerge.

(i) **No upgrade** (NU, NU). Both retailers do not purchase the quality upgrade. Because retailers stick with their ex ante homogeneous quality, their prices are the canonical Bertrand prices: the unique equilibrium is determined by the retailers' price floor, which in our setting is the per-unit fee w charged by the intermediary.

(ii) **Joint upgrade** (U, U). Both retailers purchase the quality upgrade. Therefore, retailers are ex ante and ex post homogeneous and, as a result, there is Bertrand competition. As in the previous scenario, retailers set a price equal to w and obtain zero profits.

(iii) **Asymmetric upgrade** (U, NU), (NU, U). Only one retailer purchase the quality upgrade. This case is consistent with the baseline setting in which there is vertical differentiation between retailers. However, the retailer with the higher quality incurs a fixed upgrading cost F. We denote the profits of the upgrading and non-upgrading retailers as π_H and π_L, respectively. Note that these profits, gross of the upgrading fee, are equivalent to those in the baseline setting for a given fee.

Independently of whether the asymmetric cases lead to one of the two excluding equilibria or a market sharing equilibrium, the game in Period 2 can be represented in the normal form, as depicted in Figure 1.5.

		Retailer -i	
		U	NU
Retailer i	U	$0-F, 0-F$	$\pi_H - F, \pi_L$
	NU	$\pi_L, \pi_H - F$	$0, 0$

Figure 1.5. Upgrading decision stage.

The symmetric scenarios, characterized by joint upgrade (U, U) or no upgrade (NU, NU), would drive profits to zero for any w. Hence, it becomes (weakly) dominant for retailers to adopt an asymmetric scenario, such as (U, NU) or (NU, U), where one retailer chooses to upgrade while the other does not. As a result, a coordination problem arises, leading to the emergence of asymmetric upgrading as the equilibrium outcome. This finding implies that, in the equilibrium, there exist two asymmetric scenarios that involve vertical differentiation between retailers. These scenarios, where one retailer offers a higher quality product due to the upgrade, and the other sticks to the baseline quality, provide a microfoundation for our baseline model's assumptions[14]

Hereafter, the analysis is identical to the baseline model in which retailers are exogenously asymmetric in quality. As shown in Proposition 2, the intermediary sets in the first stage $w^{H1} = q_L/2$ and induces the first excluding equilibrium in which prominence is awarded to the high-quality retailer and Bertrand-like competition is triggered. In this scenario, the

[14]Note that a mixed strategy equilibrium exists in which retailers mix between purchasing or not purchasing the upgrade. However, this equilibrium is unstable and can be broken if retailers are allowed to communicate or make the upgrade decision non-simultaneously. Therefore, we will not consider the mixed strategy equilibrium in our analysis.

retailer that purchases the upgrade obtains prominence. Because the intermediary can use the fixed fee to extract surplus, it is intuitive that it would set it to an incentive-compatible level, i.e., $F = \pi_H^{H1}(p_H^{H1}, p_L^{H1}, w^{H1}, F) - \pi_L^{H1}(p_L^{H1}, p_H^{H1}, w^{H1}) = (q_H - q_L)/4$. With this fee, the intermediary can fully extract the surplus of the high-quality retailer and obtain the same profit that it would obtain if it were a multiproduct monopolist, i.e., $\Pi^{H1}(F^\star, p_H^{H1}, p_L^{H1}, w^{H1}) = q_H/4$ which is the same as in (1.10). We summarize the results in the following proposition.

Proposition 4. *An intermediary can extract the entirety of retailers' surplus and reach the profit level of a multiproduct monopolist by offering a quality upgrade and triggering competition for prominence.*

The above result has important policy implications and welfare effects. First, the fact that the intermediary can replicate the multiproduct monopolist's profit by using a two-part tariff ensures the largest rent extraction from retailers. Notably, retailers' surplus remains the same compared to when retailers are of low quality, and the intermediary does not offer a quality upgrade. Indeed, in such a case, retailers would ultimately receive zero surplus due to Bertrand-like competition.

Note that the redistribution of surplus from the retailers to the intermediary in the quality upgrade scenario benefits consumers. If retailers are of low quality and the intermediary does not offer a quality upgrade program, consumers would have to pay a price of $p_L = w = q_L/2$. In contrast, when the asymmetric upgrading scenario arises, purchasing consumers would pay a higher price, $p_H = q_H/2$, for a better service. The net effect is positive for consumers as the higher quality more than compensates the monetary losses, resulting in a higher consumer surplus:

$$CS_{(NU,NU)} \equiv \int_{\frac{p_L}{q_L}}^{1} (\theta q_L - p_L)\, d\theta = \frac{q_L}{8} < \frac{q_H}{8} = \int_{\frac{p_H}{q_H}}^{1} (\theta q_H - p_H)\, d\theta \equiv CS_{(U,NU),(NU,U)},$$

for any $q_H > q_L$. Therefore, competition for prominence and the endogenous quality upgrading program positively affect the intermediary and consumers, whereas retailers' surplus remains unchanged.

1.5.2 Alternative scheme: Auction-based prominence

In many e-commerce and online marketplaces, various strategies for product prominence allocation have emerged, each designed to enhance visibility and drive sales. One key approach is the one presented in the baseline model in Section 1.4, which reflects the main features of Amazon's buy-box. Another widely adopted business strategy involves assigning the most prominent position through an auction process. In this scenario, the retailer placing the highest bid is granted prominence. A notable example of a marketplace in the retailing sector that uses this approach is eBay. The auction allows retailers to gain a prominent display, thereby attracting a significant portion of clicks.[15]

In this section, we compare the prominence allocation scheme of Section 1.4 with an auction-based alternative. To this end, we develop a model in which the intermediary continues to monetize its intermediation service with the per-unit fee, w, but also makes profits directly from the assignment of prominence via a second-price sealed bid auction. In this auction, a retailer secures prominence by bidding the highest (fixed) fee and paying an amount equivalent to the second-highest bid. Naturally, this alternative prominence scheme changes the timing of the game relative to the baseline model. Unlike in the competition for prominence setting, retailers now compete in prices after observing which retailer has received prominence. These differences mirror real-world dynamics, as retailers adjust their prices knowing whether their listing will be promoted. Note that this change of timing plays a crucial role in the retailers' pricing strategies: as competition occurs upon observing the intermediary's prominence allocation choice, retailers do not have incentives to compete fiercely. In combination with the quality difference among retailers, competition is softened compared to the competition for prominence case, leading to double marginalization.

The timing in this scenario is now the following. In the first stage, retailers submit their bids simultaneously. Then, the intermediary assigns prominence to the bidder submitting the highest offer and optimally chooses w. In the second stage, having observed which retailer obtains prominence, retailers compete in prices by setting p_H and p_L. Finally, consumers make their purchasing decisions, whereby passive consumers can only decide between acquiring the sponsored product or not buying.

[15] There is empirical evidence that a better ranking matters (Ursu, 2018) and that a large share of searches happens passively, where consumers merely react to online ads (Ursu et al., 2022).

If the high-quality retailer is prominent, the gross profits of the high- and low-quality retailers are, respectively:

$$\pi_H^H(p_H, p_L) = \Big[\lambda D_H^{\lambda}(p_H, p_L) + (1-\lambda) D_H^{1-\lambda}(p_H)\Big](p_H - w),$$
$$\pi_L^H(p_L, p_H) = \Big[\lambda D_L^{\lambda}(p_L, p_H)\Big](p_L - w).$$

Instead, if the low-quality retailer is prominent, the gross profits of the retailers are:

$$\pi_H^L(p_H, p_L) = \Big[\lambda D_H^{\lambda}(p_H, p_L)\Big](p_H - w),$$
$$\pi_L^L(p_L, p_H) = \Big[\lambda D_L^{\lambda}(p_L, p_H) + (1-\lambda) D_L^{1-\lambda}(p_L)\Big](p_L - w).$$

The net profit of the retailer i that wins the auction and pays a monetary compensation to the intermediary to obtain prominence, denoted by $\tilde{\pi}_i^i$, is equivalent to the gross profit of the same retailer, net of the payment made to the intermediary, which we refer to as b_i. Specifically, $\tilde{\pi}_i^i(p_i, p_{-i}) = \pi_i^i(.) - b_i$.

In stage 2, retailers set prices. With a slight abuse of notation, we denote the best replies in the continuation game in which the high-quality retailer is prominent as follows:

$$p_H^H(p_L) := \arg\max_{p_H} \Big(\lambda D_H^{\lambda}(p_H, p_L) + (1-\lambda) D_H^{1-\lambda}(p_H)\Big)(p_H - w) - b_H,$$

$$p_L^H(p_H) := \arg\max_{p_L} \lambda D_L^{\lambda}(p_L, p_H)(p_L - w).$$

Similarly, in the continuation game in which the low-quality retailer is prominent, the best replies are given by:

$$p_H^L(p_L) := \arg\max_{p_H} \lambda D_H^{\lambda}(p_H, p_L)(p_H - w),$$

$$p_L^L(p_H) := \arg\max_{p_L} \Big(\lambda D_L^{\lambda}(p_L, p_H) + (1-\lambda) D_L^{1-\lambda}(p_L)\Big)(p_L - w) - b_L.$$

Solving simultaneously, we can determine the equilibrium pair of prices which we denote as (p_H^H, p_L^H) and (p_H^L, p_L^L) for the two continuation games, respectively.

In stage 1, retailers participate in the auction, whose bids are equal to their willingness to pay for prominence, determined as the marginal benefit of being prominent. Denoting it by WTP_i for $i = L, H$, we get:

$$WTP_L := \pi_L^L(p_L^L, p_H^L) - \pi_L^H(p_L^H, p_H^H),$$
$$WTP_H := \pi_H^H(p_H^H, p_L^H) - \pi_H^L(p_H^L, p_L^L).$$

Because of its superior quality, the high-quality retailer, once prominent, has more to gain than the rival. In the Appendix, we formally show that $WTP_H > WTP_L$. We summarize this result in the following lemma.

Lemma 3. *In the auction-based prominence allocation, the high-quality retailer submits the highest bid and is awarded prominence. Both retailers make strictly positive sales and profits.*

We can now compare the market outcomes of the competition for prominence and the auction-based prominence scheme (denoted by A). In the Appendix, we identify the optimal commission fee w and calculate the resulting equilibrium profit of the intermediary. Comparing profits of the intermediary in the auction-based prominence allocation scheme with those emerging in the first excluding equilibrium (1.8), we find that $\Pi^A < \Pi^{H1}$. In other words, the intermediary always makes more profits under competition for prominence as this scheme drives retailers to lower their prices, mitigating double marginalization. Instead, an auction-based system would soften competition and avoid the exclusion of the low-quality retailer. In the latter case, the commission fee w generates a substantial double marginalization problem, which leads prices above the monopoly level that, in turn, reduce consumers' demand. Interestingly, the fee collected by the intermediary via the auction does not compensate for the lower profits generated by the per-transaction fee w. As a result, an auction-based prominence is sub-optimal to the intermediary relative to competition for prominence. It is also worth noting that in the competition for prominence scheme, the interests of the intermediary and those of the consumers are fully aligned since the intermediary aims to maximize total transactions. In the auction-based system, this is no longer the case as the intermediary takes into account both consumer demand and the fee collected from the prominent retailer, which makes the intermediary also account for the interests of the retailers. In turn, prices are higher in this case because of the softening of the competition and the double marginalization ultimately hurts consumers. A fortiori, consumer surplus is higher under competition for prominence than under an auction-based prominence scheme. We can therefore conclude with the following proposition.

Proposition 5. *Competition for prominence is more profitable for an intermediary and generates a higher consumer surplus than an auction-based prominence allocation.*

It remains to compare how retailers perform under this allocation scheme relative to the competition for prominence. Note that it is immediate that the low-quality retailer is better off in the auction setting as it makes sales, even without obtaining prominence. The high-quality retailer, instead, faces a trade-off. Under competition for prominence, the high-quality retailer benefits from the absence of double marginalization and higher demand, but the intense competition drives prices down. Under the auction, the high-quality retailer benefits from the softened competition, but fees reduce its revenues.

Due to tractability reasons, we can only prove the existence of this trade-off numerically. Assuming without loss of generality the following value for the low-quality retailer $q_L = 5/4$, Figure 1.6 illustrates the areas in which the retailers' profits are higher under competition for prominence (i.e., the orange area) and auction-based prominence (i.e., the blue area), respectively.

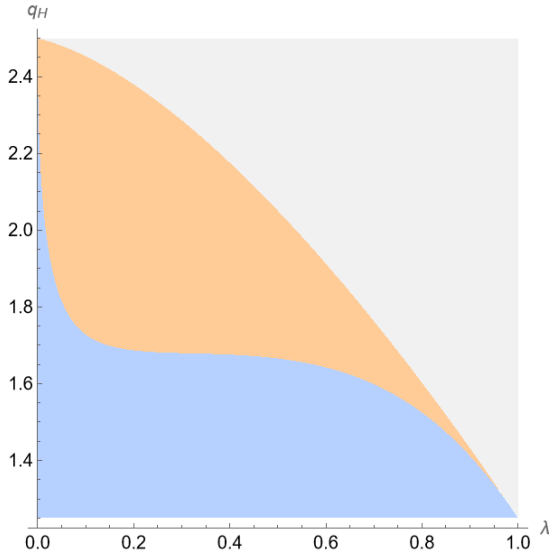


Figure 1.6. Profit comparison of the high-quality retailer in the two prominence allocation schemes. ($q_L = 5/4$)

Figure 1.6 shows that the high-quality retailer can be better off with either prominence schemes depending on the parameter range. In particular, its profits are higher in an auction-based system when a small quality differential and/or the number of active consumers is very large. The intuition is that in this scenario, the two retailers are almost symmetric, and there is little gain

for competing fiercely for the prominent allocation. In turn, the high-quality can secure its prominence allocation under an auction-based prominence by paying a very small fee while benefiting from a softened competition. On the contrary, as the number of passive consumers gets larger, attracting them becomes important for both retailers, increasing their willingness to pay for prominence (and the associated fee). If the quality differential gets larger as well, then the high-quality retailer can obtain higher profits under competition for prominence since, due to the high quality, its price does not decrease too much. As a result, the high-quality retailer is better off under competition for prominence for a large share of passive consumers and a large quality differential.

1.6 Conclusions

This paper provides insights into prominence schemes that intermediaries can implement. Competition for prominence emerges as a powerful mechanism to tackle the issue of double marginalization and benefit consumers by inducing lower equilibrium prices.

Our analysis shows that the low- or high-quality retailer can obtain prominence depending on whether the commission fee is treated as given or chosen contingently by the intermediary. If the commission fee is considered as given, which could be due to long-run commitments or external regulation, competition for prominence can result in a scenario where low-quality retailers are promoted to passive consumers. This situation arises when the share of passive consumers is not significant enough to intensify competition between the two retailers, and the quality of the low-quality retailer is not deemed "too low". Consequently, competition softens, and the intermediary promotes the low-quality retailer to passive consumers. In all other cases, competition between the two retailers intensifies, as both retailers cannot afford to overlook the passive segment. Such intense competition can lead to two alternative equilibria, where the low-quality retailer makes no sale. If the commission fee is low, the Bertrand-like competition culminates with the high-quality retailer setting a low price. On the other hand, if the commission fee is high, the competition concludes with the high-quality retailer setting a high (monopoly-like) price.

However, when the intermediary can promptly adjust the fee based on market circumstances, it will strategically induce the excluding equilibrium

where prices are low, and competition is intense, as this outcome allows the intermediary to replicate the market outcomes of a multiproduct monopolist. In this equilibrium, the low-quality retailer serves no consumers but plays a crucial role in compelling the high-quality retailer to lower its price and expand demand. In turn, this strategy benefits consumers by providing access to a lower-priced high-quality product while optimizing the intermediary's overall profits.

Our analysis also shows that alternative prominence allocation schemes, such as auctions, are suboptimal for the intermediary and consumers compared to competition for prominence. Auction schemes require the intermediary to commit to granting prominence to a particular retailer, leading to a relaxation of competition, which lowers demand. However, retailers' total surplus can be higher in an auction-based prominence scheme. This result suggests that all welfare effects should be taken into account by policymakers and authorities when intervening against steering mechanisms, and a possible trade-off between the two types of users (i.e., final consumers and business users) may ultimately be present. Indeed, our research highlights the need for careful deliberation in designing prominence allocation mechanisms to ensure they do not result in negative welfare effects. It is essential to strike a balance that promotes competition and efficiency while safeguarding the interests of all stakeholders involved.

In addition, this paper provides a rationale for why major retail companies, such as Walmart in the United States or FNAC in France, have started implementing a platform business model that allows third-party sellers to operate on their marketplace. These platforms gather all product listings in one location and highlight one through their version of the buy-box, representing consumers' default option. This trend suggests that new entrants in this industry acknowledge the importance of competition for prominence as a critical factor in achieving success. Furthermore, our analysis sheds light on how the vertical differentiation between two identical offers can be determined by the decision of the intermediary to offer ancillary services, which has also become an emerging practice in the industry.[16] We find that if an intermediary can steer passive consumers using a prominent display and offers the possibility to upgrade the quality of ancillary services, it can extract the largest surplus from retailers. This strategy is the most profitable

[16] For example, Walmart offers the Walmart Fulfillment Services: https://marketplace.walmart.com/walmart-fulfillment-services/.

for the intermediary because it removes double marginalization and increases consumer surplus. However, it comes at the cost of leaving both retailers without surplus.

Recently, Amazon attracted the attention of antitrust authorities for possible suspected anti-competitive practices related to the buy-box. At the end of 2022, Amazon settled the European Commission's investigations by offering, among other commitments, to display a second competing offer to the Buy Box winner.[17] Our findings suggest that the commitment proposed may only partially address the surplus extraction issue that can arise from the assignment of a buy-box. The criteria used by the intermediary may still stimulate fierce competition among retailers and allow for monopolistic rent extraction through its fee structure. Hence, thoughtful consideration and thorough evaluation are necessary to devise prominence allocation schemes to optimize market outcomes and maximize welfare for all participants.

[17] See: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7777.

1.7 Appendix

Proof of Lemma 1

This proof immediately follows from the main text.

Proof of Lemma 2

The first part of the proof follows from (1.3). Suppose that H is prominent. It can set two prices: either it sets $p_H = p_L q_H / q_L$ so that (1.3) binds, or it sets $p_H < p_L q_H / q_L$ and the constraint in (1.3) is slack. Suppose $p_H = p_L q_H / q_L$. In this case, L's demand conditional on H being prominent is:

$$\begin{aligned} D_L^{\lambda}(p_L, p_H) =& \frac{\frac{q_H}{q_L} p_L - p_L}{q_H - q_L} - \frac{p_L}{q_L} \\ =& \frac{p_L}{q_L} - \frac{p_L}{q_L} \\ =& 0, \end{aligned}$$

which implies the exclusion of L for any $p_L \geq w$. Because L leaves the market for $p_H = p_L q_H / q_L$, it is also excluded for any $p_H < p_L q_H / q_L$. As a result, the equilibrium price set by H conditional on being prominent is $p_H = p_L q_H / q_L$, and $D_L^{\lambda}(p_L, p_H) = 0$.

The second part of the proof is as follows. Suppose L is prominent: in this case, H is out of the market (i.e., $D_H^{\lambda} = 0$) if, and only, if:

$$p_L \leq p_H - q_H + q_L.$$

Suppose L sets its lowest price $p_L = w$. Then, exclusion of H occurs if and only if:

$$w \leq p_H - q_H + q_L,$$

or alternatively if $p_H \geq w + q_H - q_L$.

Suppose also H sets the lowest possible price $p_H = w$. Then, H is out of the market if and only if $q_L \geq q_H$, which contradicts the assumption that $q_H > q_L$. As a result, if L is awarded prominence it cannot exclude H from the marketplace. This concludes the proof.

Proof of Proposition 1

To determine the pricing strategies employed by the retailers, we first identify the best reply of the two retailers for a given prominence allocation.

Low-quality-retailer. If the low-quality retailer is prominent, L chooses p_L to maximize the following program:

$$\max_{p_L} \pi_L^L(p_L, p_H) \equiv \Big[\lambda\Big(\frac{p_H - p_L}{q_H - q_L} - \frac{p_L}{q_L}\Big) + (1-\lambda)\Big(1 - \frac{p_L}{q_L}\Big)\Big](p_L - w).$$

The low-quality retailer's price is determined by solving the first-order condition of the profit with respect to p_L, which yields

$$\frac{\partial \pi_L^L(p_L, p_H)}{\partial p_L} = \frac{\lambda(p_H - 2p_L - q_H + q_L + w)}{q_H - q_L} + \frac{q_L - 2p_L + w}{q_L} = 0.$$

Solving for $p_L(p_H)$ gives:

$$p_L(p_H) = \frac{\lambda q_L(p_H - q_H + q_L + w) + (q_H - q_L)(q_L + w)}{2(q_H - (1-\lambda)q_L)}. \tag{1.11}$$

Note that this price should respect the following two constraints: (i) $p_L < p_H q_L/q_H$, which guarantees that the prominence is allocated to the low-quality firm (Lemma 1); (ii) $p_L \geq w$, which guarantees a non-negative profit. We verify these conditions in what follows:

(i) $p_L(p_H) < p_H q_L/q_H$ if and only if:

$$\begin{aligned} p_L(p_H) \equiv & \frac{\lambda q_L(p_H - q_H + q_L + w) + (q_H - q_L)(q_L + w)}{2(q_H - (1-\lambda)q_L)} < p_H \frac{q_L}{q_H}, \\ \Leftrightarrow \; & p_H \; \frac{q_H(q_H((1-\lambda)q_L + w) - (1-\lambda)q_L(q_L + w))}{q_L((2-\lambda)q_H - 2(1-\lambda)q_L)} \equiv \hat{p}_H. \end{aligned}$$

(ii) $p_L(p_H) \geq w$ if and only if:

$$\begin{aligned} p_L(p_H) \equiv & \frac{\lambda q_L(p_H - q_H + q_L + w) + (q_H - q_L)(q_L + w)}{2(q_H - (1-\lambda)q_L)} \geq w, \\ \Leftrightarrow \; & p_H \geq \frac{(q_H - q_L)(w - q_L)}{\lambda q_L} + q_H - q_L + w \equiv \tilde{p}_H. \end{aligned}$$

Note that comparing $\tilde{p}_H$ with $\hat{p}_H$, we observe that $\hat{p}_H - \tilde{p}_H > 0$, i.e.:

$$\hat{p}_H - \tilde{p}_H = \frac{2(1-\lambda)(q_H - q_L)(q_L - w)(q_H - (1-\lambda)q_L)}{\lambda q_L((2-\lambda)q_H) - 2(1-\lambda)q_L} > 0,$$

meaning that constraints (i) and (ii) are satisfied as long as $p_H \geq \hat{p}_H$.

From Lemma 2, we know that for $p_L \geq p_H q_L/q_H$, the low-quality retailer has zero overall demand and the high-quality serves the entire market.

Therefore, for any price that H sets between $\hat{p_H}$ and wq_L/q_H, L has an incentive to undercut its rival by an $\varepsilon \to 0$ such that the prominence allocation rule favors the low-quality retailer. Instead, for $p_H \leq wq_H/q_L$, the low-quality retailer can only set its minimum price of $p_L = w$.

The best-responses of L is thus determined as follows:

$$p_L(p_H) = \begin{cases} \frac{\lambda q_L(p_H - q_H + q_L + w) + (q_H - q_L)(q_L + w)}{2(q_H - (1-\lambda)q_L)}, & \text{if } p_H \geq \hat{p}_H, \\ p_H \frac{q_L}{q_H} - \varepsilon, & \text{if } w\frac{q_L}{q_H} < p_H < \hat{p}_H, \\ w, & \text{if } p_H \leq w\frac{q_H}{q_L}. \end{cases} \tag{1.12}$$

High-quality-retailer. If the low-quality retailer is prominent, H chooses p_H to maximize the following program:

$$\max_{p_H} \pi_H(p_H, p_L) \equiv \lambda\Big(1 - \frac{p_H - p_L}{q_H - q_L}\Big)(p_H - w).$$

The high-quality retailer's price is determined by solving the first-order condition of the profit with respect to p_H, which yields:

$$\frac{\partial \pi_H(p_H, p_L)}{\partial p_H} = \frac{\lambda(p_L - 2p_H + q_H - q_L + w)}{q_H - q_L} = 0.$$

Solving for $p_H(p_L)$ gives:

$$p_H(p_L) = \frac{1}{2}(p_L + q_H - q_L + w). \tag{1.13}$$

Note that this price is feasible subject to the following constraint: $p_H > p_L q_H/q_L$, which guarantees that the prominence is allocated to the low-quality firm (Lemma 1). Therefore, $p_H(p_L) > p_L q_H/q_L$ if and only if

$$\begin{aligned} p_H(p_L) \equiv & \frac{1}{2}(p_L + q_H - q_L + w) > p_L \frac{q_H}{q_L} \\ \Leftrightarrow \; & p_L < \frac{q_H q_L - q_L^2 + q_L w}{2q_H - q_L} \equiv \tilde{p}_L. \end{aligned}$$

From Lemma 2, we know that for $p_H \leq p_L q_H/q_L$, the high-quality serves the entire market. Therefore, if the price of L is sufficiently low, H can match its rival and obtain prominence by setting $p_H = p_L q_H/q_L$. However, if the price set by the low-quality retailer is sufficiently high, H can set the monopoly price of $(q_H + w)/2$, which is obtained by maximizing the following program:

$$\max_{p_H} \pi_H^H(p_H, p_L) \equiv \Big(1 - \frac{p_H}{q_H}\Big)(p_H - w).$$

Indeed, $p_H(p_L) \leq p_L q_H/q_L$ if and only if

$$\begin{aligned} p_H(p_L) \equiv & \frac{q_H + w}{2} \leq p_L q_H/q_L, \\ \Leftrightarrow \;\; & p_L \geq \frac{q_H q_L + q_L w}{2q_H} \equiv \hat{p}_L. \end{aligned}$$

Note that comparing $\tilde{p}_L$ with $\hat{p}_L$, we observe that $\hat{p}_L - \tilde{p}_L > 0$, i.e.,

$$\hat{p}_L - \tilde{p}_L = \frac{q_H q_L^2 - q_L^2 w}{4q_H^2 - 2q_H q_L} > 0.$$

The best-responses of H is thus determined as follows:

$$p_H(p_L) = \begin{cases} \frac{1}{2}(p_L + q_H - q_L + w), & \text{if } \; p_L < \tilde{p}_L, \\ p_L \frac{q_H}{q_L}, & \text{if } \; \hat{p}_L > p_L \geq \tilde{p}_L, \\ \frac{q_H + w}{2}, & \text{if } \; p_L \geq \hat{p}_L. \end{cases} \tag{1.14}$$

Equilibrium analysis. Having determined the best replies of the two firms, we can now identify the equilibrium prices for a given w. Specifically, we verify under which conditions the two alternative equilibria in Lemma 2 exists.

- **Market sharing equilibrium.** Solving the system of first order conditions in (1.11) and (1.13) simultaneously, we have:

$$\begin{aligned} p_L(w) &= \frac{\lambda q_L(3w - q_H + q_L) + 2(q_H - q_L)(q_L + w)}{4q_H - (4 - 3\lambda)q_L}, \\ p_H(w) &= \frac{2q_H^2 - (3 - \lambda)q_H q_L + 3q_H w + (1 - \lambda)q_L(q_L - 3w)}{4q_H - (4 - 3\lambda)q_L}. \end{aligned} \tag{1.15}$$

We can now ex post verify whether $p_L < \tilde{p}_L$ and $p_H \geq \hat{p}_H$ (first line in (1.12)).

(i) $p_L < \tilde{p}_L$ if and only $p_L(w)$ in (1.15) satisfies the following:

$$\begin{aligned} & p_L(w) \equiv \frac{2q_H^2 - (3 - \lambda)q_H q_L + 3q_H w + (1 - \lambda)q_L(q_L - 3w)}{4q_H - (4 - 3\lambda)q_L} \\ & < \frac{q_H q_L + q_L w}{2q_H} \equiv \tilde{p}_L \\ \Leftrightarrow \;\; & - \frac{2(q_H - q_L)\left(\lambda q_H q_L - 2q_H w + (\lambda - 1)q_L^2 - 3(\lambda - 1)q_L w\right)}{(2q_H - q_L)(4q_H + (3\lambda - 4)q_L)} < 0 \\ \Leftrightarrow \;\; & \lambda q_H q_L - 2q_H w + (\lambda - 1)q_L^2 - 3(\lambda - 1)q_L w > 0. \end{aligned} \tag{1.16}$$

which is the case if and only if the following two conditions are jointly satisfied:

$$(a)\ \ w < \frac{q_L}{2}, \qquad (b)\ \ \tilde{\lambda} \equiv \frac{2q_H w + q_L^2 - 3q_L w}{q_H q_L + q_L^2 - 3q_L w} < \lambda < 1.$$

(ii) $p_H \geq \hat{p}_H$ if and only $p_H(w)$ in (1.15) satisfies the following:

$$\begin{aligned} & p_H(w) \equiv \frac{2q_H^2 - (3-\lambda)q_H q_L + 3q_H w + (1-\lambda)q_L(q_L - 3w)}{4q_H - (4-3\lambda)q_L} \geq \\ & \frac{q_H(q_H((1-\lambda)q_L + w) - (1-\lambda)q_L(q_L + w))}{q_L((2-\lambda)q_H - 2(1-\lambda)q_L)} \equiv \hat{p}_H \\ \Leftrightarrow & \frac{2(q_H - q_L)(q_H - (1-\lambda)q_L)\left(\lambda q_H q_L - 2q_H w - (1-\lambda)q_L^2 + 3(1-\lambda)q_L w\right)}{q_L((2+\lambda)q_H - 2(1-\lambda)q_L)(4q_H - (4-3\lambda)q_L)} > 0 \\ \Leftrightarrow & \lambda q_H q_L + 2q_H w + (1-\lambda)q_L^2 + 3(1-\lambda)q_L w > 0. \end{aligned}$$

where the last line is the same as the last line in (1.16). Therefore, $p_L < \tilde{p}_L$ and $p_H \geq \hat{p}_H$ are jointly satisfied if and only if the following two conditions are jointly satisfied:

$$(a)\ \ w < \frac{q_L}{2}, \qquad (b)\ \ \tilde{\lambda} \equiv \frac{2q_H w + q_L^2 - 3q_L w}{q_H q_L + q_L^2 - 3q_L w} < \lambda < 1.$$

Therefore, there exists a market sharing equilibrium if and only if $w < q_L/2$ and $\lambda \in (\tilde{\lambda}, 1]$.

- **Excluding equilibria.** The equilibria exist if either $w \geq q_L/2$ or if $w < q_L/2$ and $\lambda \leq \tilde{\lambda}$. If either are verified, the best-response of L is always to set $p_L = w$ whereas H has two choices: (i) set $p_H = (q_H + w)/2$ or, alternatively, (ii) $p_H q_L/q_H$.

  (i) First, we note that $p_H = (q_H + w)/2$ can be a best-response to $p_L = w$ if and only if $p_H \leq w q_L/q_H$ (third line in (1.12)), namely if:

$$\begin{aligned} & \frac{q_H + w}{2} \leq w\frac{q_H}{q_L} \\ \Leftrightarrow\ & w \geq \frac{q_H q_L}{2q_H - q_L}. \end{aligned}$$

  Therefore, H sets a monopoly price if w is large enough. Otherwise, the next equilibrium is feasible.

(ii) If $w < (q_H q_L)/(2q_H - q_L)$, H responds to $p_L = w$ by setting $p_H(p_L) = p_L q_L/q_H$, that is $p_H = wq_L/q_H$, which a fortiori satisfies the constraint for which $p_L = w$ (third line in (1.12)).

Thus, we conclude the following. For any given w, we have the following three equilibria:

1. if $w < q_L/2$ and $\lambda \in (\tilde{\lambda}, 1]$, there is a unique market sharing equilibrium and prices are as in (1.15). In this case, retailers' profits are given by:

$$\pi_L^L(\cdot) = \frac{(q_H - q_L)(q_H - (1-\lambda)q_L)(2w - (2-\lambda)q_L)^2}{q_L(4q_H - (4-3\lambda)q_L)^2},$$
$$\pi_H^L(\cdot) = \frac{\lambda(q_H - q_L)(q_L + w - 2q_H - \lambda q_L)^2}{(4q_H - (4-3\lambda)q_L)^2}.$$

2. otherwise, there is a unique excluding equilibrium and prices are

   2.1.) $p_L = w$ and $p_H = wq_L/q_H$ if $w \leq (q_H q_L)/(2q_H - q_L)$; in this case, the low-quality retailer makes no sales, the high-quality retailer obtains $\pi_H^{H1}(\cdot) = w(q_H - q_L)(q_L - w)/q_L^2$.

   2.2.) $p_L = w$ and $p_H = (q_H + w)/2$ if $w > (q_H q_L)/(2q_H - q_L)$; in this case, the low-quality retailer makes no sales, the high-quality retailer obtains $\pi_H^{H2}(\cdot) = (q_H - w)^2/(4q_H)$.

This concludes the proof.

Proof of Proposition 2

Suppose we are in the market sharing equilibrium. This case exists if the equilibrium fee w is less than $q_L/2$. The intermediary maximizes the following profit:

$$\Pi^L(\cdot) = \frac{\lambda q_L w(q_H + 2q_L - 3w) + 2w(q_H - q_L)(q_L - w)}{q_L(4q_H - (4-3\lambda)q_L)},$$

s.t. $w < q_L/2$. From the unconstrained optimization, denoting $w^L = \arg\max_w \Pi^L(\cdot)$, i.e.:

$$w^L = \frac{q_L((\lambda+2)q_H + 2(\lambda-1)q_L)}{4q_H + 6\lambda q_L - 4q_L},$$

it is immediate to note that the $w^L > q_L/2$. Therefore, it does not satisfy the constraint and the intermediary can set as much as $w = q_L/2 - \varepsilon$ with $\varepsilon \to 0$,

which leads to the following profit:

$$\Pi^{L}(\cdot) \approx \frac{q_L(2(\lambda+1)q_H - (2-\lambda)q_L)}{4(4q_H - (4-3\lambda)q_L)}. \tag{1.17}$$

Suppose we are in the first excluding equilibrium where $p_H^{H1} = wq_H/q_L$. This case exists if and only if the equilibrium fee w is less or equal than $(q_H q_L)/(2q_H - q_L)$. For a given w, the profit of the intermediary is:

$$\Pi^{H1}(\cdot) = \frac{w(q_L - w)}{q_L}.$$

Differentiating it with respect to w we obtain the following equilibrium fee $w = q_L/2$, and the associated equilibrium profit of the intermediary is $\Pi^{H1}(\cdot) = q_L/4$. Note that this profit is always larger than the one in (1.17). Thus, we can already conclude that the market sharing equilibrium never occurs.

Suppose now that we are in the second excluding equilibrium where $p_H^{H2} = (q_H + w)/2$. This case exists if and only if the equilibrium fee w is more than $(q_H q_L)/(2q_H - q_L)$. For a given w, the profit of the intermediary is:

$$\Pi^{H2}(\cdot) = w - \frac{w(q_H + w)}{2q_H}$$

s.t. $w > (q_H q_L)/(2q_H - q_L)$. Differentiating it with respect to w we obtain $w^{H2} = q_H/2$. From the unconstrained optimization, denoting $w^{H2} = \arg\max_w \Pi^{H2}(\cdot)$, i.e.:

$$w^{L} = \frac{q_L((\lambda+2)q_H + 2(\lambda-1)q_L)}{4q_H + 6\lambda q_L - 4q_L},$$

which is larger than $(q_H q_L)/(2q_H - q_L)$ if and only if $q_H \geq 3q_L/2$. In this case, the associated profit is $\Pi^{H2}(\cdot) = q_H/8$. Otherwise, the intermediary sets the constrained fee $w = (q_H q_L)/(2q_H - q_L) - \varepsilon$ where $\varepsilon \to 0$ and the associated profit is:

$$\Pi^{\overline{H2}}(\cdot) \approx \frac{q_H q_L(q_H - q_L)}{(q_L - 2q_H)^2}.$$

Comparing profits in the different scenarios, we observe that:

$$\Pi^{H1}(\cdot) - \Pi^{H2}(\cdot) = \frac{q_L}{4} - \frac{q_H}{8} > 0,$$

which holds if and only if $q_L > q_H/2$, which is ensured by our assumption. Moreover:

$$\Pi^{H1}(\cdot) - \Pi^{\overline{H2}}(\cdot) = \frac{q_L}{4} - \frac{q_H q_L(q_H - q_L)}{(q_L - 2q_H)^2} > 0,$$

which holds always.

Thus, the intermediary maximizes its profit with $w = q_L/2$ and the first excluding equilibrium arises as a Subgame Perfect Nash Equilibrium.

Welfare In equilibrium, dropping the arguments for brevity, consumer surplus is given by:

$$CS^{H1}(\cdot) = \lambda \int_{\frac{p_H - p_L}{q_H - q_L}}^{1} (\theta q_H - p_H)\, d\theta + (1-\lambda) \int_{\frac{p_H}{q_H}}^{1} (\theta q_H - p_H)\, d\theta = \frac{q_H}{8}. \quad (1.18)$$

The total industry profit is:

$$\Pi^{H1}(\cdot) + \pi_H^{H1}(\cdot) = \frac{q_H}{4}. \quad (1.19)$$

Total welfare, which is defined as the sum of the industry profit and consumer surplus, is:

$$W^{H1}(\cdot) = CS^{H1}(\cdot) + \Pi^{H1}(\cdot) + \pi_H^{H1}(\cdot) = \frac{3}{8} q_H. \quad (1.20)$$

Proof of Lemma 3

For any given w, the profits of the retailers conditional on L being prominent, are given by:

$$\pi_L^L(p_L, p_H) = \Big[\lambda D_L^{\lambda}(p_L, p_H) + (1-\lambda) D_L^{1-\lambda}(p_L)\Big](p_L - w) - b_L,$$
$$\pi_H^L(p_H, p_L) = \lambda D_H^{\lambda}(p_H, p_L)(p_H - w).$$

Differentiating them with respect to p_L and p_H, respectively, yields:

$$\frac{\partial \pi_L^L(p_L, p_H)}{\partial p_L} = 0 \iff p_L^L(p_H) = \frac{\lambda q_L(p_H - q_H + q_L + w) + (q_H - q_L)(q_L + w)}{2(q_H - (1-\lambda)q_L)},$$
$$\frac{\partial \pi_H^L(p_H, p_L)}{\partial p_H} = 0 \iff p_H^L(p_L) = \frac{1}{2}(p_L + q_H - q_L + w).$$

Solving simultaneously, equilibrium prices are given by:

$$p_L^L = \frac{\lambda q_L(q_L - q_H + 3w) + 2(q_H - q_L)(q_L + w)}{4q_H - (4 - 3\lambda)q_L},$$
$$p_H^L = \frac{2q_H^2 - (3-\lambda)q_H q_L + 3q_H w + (1-\lambda)q_L(q_L - 3w)}{4q_H - (4 - 3\lambda)q_L},$$

and the associated profits are:

$$\pi_L^L = \frac{(q_H - q_L)(q_H - (1-\lambda)q_L)(2w - (2-\lambda)q_L+)^2}{q_L(4q_H - (4-3\lambda)q_L)^2},$$
$$\pi_H^L = \frac{\lambda(q_H - q_L)(w - 2q_H + (1-\lambda)q_L)^2}{(4q_H - (4-3\lambda)q_L)^2}.$$

For any given w, the profits of the retailers conditional on H being prominent, are given by

$$\pi_L^H(p_L, p_H) = \Big[\lambda D_L^{\lambda}(p_L, p_H)\Big](p_L - w),$$
$$\pi_H^H(p_H, p_L) = \Big[\lambda D_H^{\lambda}(p_H, p_L) + (1-\lambda)D_H^{1-\lambda}(p_H)\Big](p_H - w) - b_H.$$

Differentiating them with respect to p_L and p_H, respectively, yields:

$$\frac{\partial \pi_L^H(p_L, p_H)}{\partial p_L} = 0 \Longleftrightarrow p_L^L(p_H) = \frac{p_H q_L + q_H w}{2q_H},$$
$$\frac{\partial \pi_H^H(p_H, p_L)}{\partial p_H} = 0 \Longleftrightarrow p_H^L(p_L) = \frac{\lambda(p_L q_H + q_L w) + (q_H - q_L)(q_H + w)}{2(q_H - (1-\lambda)q_L)}.$$

Solving simultaneously, equilibrium prices are given by:

$$p_L^H = \frac{\lambda q_L w(2q_H + q_L) + (q_H - q_L)(q_H(q_L + 2w) + q_L w)}{q_H(4q_H - (4-3\lambda)q_L)},$$
$$p_H^H = \frac{\lambda w(q_H + 2q_L) + 2(q_H - q_L)(q_H + w)}{4q_H - (4-3\lambda)q_L},$$

and the associated profits are:

$$\pi_L^H = \frac{\lambda(q_H - q_L)(q_H(q_L - 2w) + (1-\lambda)q_L w)^2}{q_H q_L(4q_H + (4-3\lambda)q_L)^2},$$
$$\pi_H^H = \frac{(q_H - q_L)(q_H - (1-\lambda)q_L)(2q_H - (2-\lambda)w)^2}{q_H(4q_H + (3\lambda - 4)q_L)^2}.$$

Denoting WTP_i the willingness to pay for prominence of retailer i, for $i = L, H$, we get:

$$WTP_L := \frac{(q_H - q_L)\left((q_H - (1-\lambda)q_L)(2w - (2-\lambda)q_L+)^2 - \Psi\right)}{q_L(4q_H - (4-3\lambda)q_L)^2},$$
$$WTP_H := \frac{(q_H - q_L)\left(\frac{(q_H - (1-\lambda)q_L)(2q_H - (2-\lambda)w)^2}{q_H} - \lambda(w - 2q_H + (1-\lambda)q_L)^2\right)}{(4q_H - (4-3\lambda)q_L)^2},$$

where $\Psi = (\lambda(q_H(q_L - 2w) + (1-\lambda)q_L w)^2)/(q_H)$. Comparing the two willingness-to-pay, we have $WTP_H - WTP_L > 0$ if

$$\frac{(1-\lambda)(q_H - q_L)\left(4q_H^2 - (8-5\lambda)q_H q_L + (4-\lambda(5-2\lambda))q_L^2\right)\left(q_H q_L - w^2\right)}{q_H q_L(4q_H - (4-3\lambda)q_L)^2} > 0$$
$$\Leftrightarrow \left(4q_H^2 - (8-5\lambda)q_H q_L + (4-\lambda(5-2\lambda))q_L^2\right) > 0 \tag{1.21}$$

which is positive since the above term is positive at $\lambda = 0$ and $\lambda = 1$, and is monotonically increasing in λ. Therefore, $WTP_H - WTP_L > 0$.

Proof of Proposition 5

Since we consider a sealed-bid second price auction, following the result established in (1.21), the fee paid by the prominent retailer is given by:

$$b_H = WTP_L.$$

The intermediary's profit when awarding prominence to the high-quality retailer is:

$$\Pi^H(\cdot) = \frac{1}{q_H q_L(4q_H - (4-3\lambda)q_L)^2}$$
$$\Big\{(q_H^3\left((4-\lambda)(1-\lambda)q_L^2 + 12\lambda q_L w + 4(1-3\lambda)w^2\right) - (1-\lambda)(8-\lambda(11-4\lambda))q_L^3 w^2)$$
$$+q_H^2 q_L\left(-\left((1-\lambda)(8-(5-\lambda)\lambda)q_L^2\right) - 3\lambda(4-3\lambda)q_L w - 2(8-7(2-\lambda)\lambda)w^2\right)$$
$$+q_H q_L^2\left((1-\lambda)(\lambda-2)^2 q_L^2 + ((4(5-\lambda)\lambda - 35)\lambda + 20)w^2\right)\Big\}.$$

Differentiating it with respect to w and solving the related first-order condition to zero yields

$$w^A = \frac{3\lambda q_H^2 q_L(4q_H - (4-3\lambda)q_L)}{\Omega + 2(1-\lambda)(8-\lambda(11-4\lambda))q_L^3 - 2(20-\lambda(35-4(5-\lambda)\lambda))q_H q_L^2},$$

where $\Omega \equiv 4(8-7(2-\lambda)\lambda)q_H^2 q_L - 8(1-3\lambda)q_H^3$.

The equilibrium profit of the intermediary under the auction-based

prominence is:

$$\begin{aligned}\Pi^A(\cdot) = \frac{1}{108}\Big[&12\lambda(q_H - q_L) + \frac{4(q_L - q_H)(5q_H + 7q_L)}{q_L} \\ &- \frac{16(q_L - 4q_H)(q_L - q_H)^3}{q_L(4q_H - (4-3\lambda)q_L)^2} + \frac{12q_H(q_H - q_L)(8q_H + q_L)}{q_L(4q_H + (4-3\lambda)q_L)}\Big] \\ &+ \frac{243\lambda^2 q_H^3 q_L}{108}\Big[2(8 - 7(2-\lambda)\lambda)q_H^2 q_L - 4(1-3\lambda)q_H^3 \\ &+ (1-\lambda)(8 - \lambda(11 - 4\lambda))q_L^3 - (20 - \lambda(35 - 4(5-\lambda)\lambda))q_H q_L^2\Big]^{-1}\end{aligned} \tag{1.22}$$

Although technically untractable, it is possible to show that $\Pi^A < \Pi^{H1}$ always, where Π^{H1} is given by (1.8).[18]

Asymmetric marginal cost

An important assumption in our baseline model is that both retailers face a common marginal cost, normalized to zero. In this section, we relax this assumption and discuss how asymmetric marginal cost alters the market outcome. Specifically, we assume that the high-quality retailer has a higher marginal cost than the low-quality retailer. Denoting c_H and c_L, respectively, the marginal cost of H and L, and normalizing the latter to 0, we assume $c_H > c_L = 0$.

This assumption has an important effect on changing how retailers compete. The reason is that the price floor of H is now $p_H = c_H + w$, whereas the price floor of L is $p_L = w$.

Conditional on H being prominent, the profits of the retailers are, respectively:

$$\begin{aligned}\pi_H^H(p_H, p_L, w) &= \Big[\lambda D_H^{\lambda}(p_H, p_L) + (1-\lambda)D_H^{1-\lambda}(p_H)\Big](p_H - w - c_H), \\ \pi_L^H(p_L, p_H, w) &= \Big[\lambda D_L^{\lambda}(p_L, p_H)\Big](p_L - w).\end{aligned}$$

[18] Formally, this is verified using *Wolfram Mathematica*. The proof is available at the following link: https://fabriziociotti.github.io/fciotti/competition-for-prominence-mathematica.rar. A similar proof is also available for what concerns the analysis of consumer surplus and retailers' profits in the two scenarios.

Conditional on L being prominent, that is for $\lambda \geq \tilde{\lambda}(w)$ are, respectively:

$$\pi_H^L(p_H, p_L, w) = \Big[\lambda D_H^{\lambda}(p_H, p_L)\Big](p_H - w - c_H),$$
$$\pi_L^L(p_L, p_H, w) = \Big[\lambda D_L^{\lambda}(p_L, p_H) + (1-\lambda) D_L^{1-\lambda}(p_L)\Big](p_L - w).$$

For any $\lambda < \tilde{\lambda}(w)$, we distinguish between two alternative scenarios, which depend on the magnitude of the marginal cost. In the first one, c_H is sufficiently low (and the baseline model is a degenerate case), and H can always match the quality-adjusted price of L and win prominence. In the second one, c_H is sufficiently high, and H cannot obtain prominence as the low-quality retailer can always undercut the high-quality one.

Using H and L's price floors together with the prominence allocation rule in (1.3), we can identify the cut-off value below (resp. above), which H is always able to undercut L and maximize the profit of the intermediary if:

$$c_H \leq (>)\Big(\frac{q_H}{q_L} - 1\Big)w. \tag{1.23}$$

If (1.23) holds, therefore, the analysis in our baseline model holds qualitatively, and the low-quality retailer is out of the market at equilibrium (see Proposition 2).

If (1.23) does not hold, it is not always possible for H to lower its price to win prominence. As in the baseline model, L is always incentivized to obtain prominence whenever H obtains prominence. Otherwise, it is excluded. Therefore, the equilibrium outcome depends on the incentives of the high-quality seller in this case.

Unlike the baseline model, no equilibrium in pure strategy exists if H has the incentive to obtain prominence.

Too see why, consider the case in which H reaches its lowest price, $p_H = w + c_H$, and L sets $p_L = p_H \; q_L/q_H - \varepsilon$ (with $\varepsilon \to 0$). In this case, L gains prominence and positive profit, whereas H obtains zero profits. Since the loss of prominence for the high-quality retailer does not imply losing the active consumers due to vertical differentiation (see Lemma 2), H is always incentivized to raise its price and monetize the actives.

Consider now the case in which L sets $p_L = (w + c_H) \; q_L/q_H - \varepsilon$ (with $\varepsilon \to 0$), which implies that L certainly obtains prominence. As H can always serve the active consumers if L is prominent (by Lemma 2), it maximizes its profit subject to $p_L = (w + c_H) \; q_L/q_H - \varepsilon$. From the first-order condition with

respect to p_H, we obtain the following candidate equilibrium price

$$p_H = \frac{c_H(q_H + q_L) + w(q_H + q_L) + q_H(q_H - q_L)}{2q_H}.$$

We notice that (p_L, p_H) here defined is not equilibrium because L can always raise its price just below the prominence threshold level, i.e., $p_L \approx p_H \, q_L/q_H - \varepsilon$.

This analysis suggests that if (1.23) does not hold, there is never an equilibrium in pure strategy. Therefore, only a mixed strategy equilibrium exists.

2

Manipulating Perceived Product Differentiation

This paper investigates the intermediary's ability to manipulate consumers' perception of product differentiation between two firms. The intermediary has the ability to decrease transportation costs for the favored firm while increasing them for its competitor. Our findings indicate that an increase in relative differentiation is advantageous for both total industry profits and consumers, albeit at the expense of the disadvantaged firm. However, the degree to which consumers benefit from this relative differentiation depends on the intermediary's chosen monetization strategy: in some instances, the intermediary may capture all the benefits, reducing consumers' surplus.

2.1 Introduction

Online intermediaries commonly employ various strategies to influence consumers' consumption choices. Traditionally, platforms have utilized monetary instruments, such as position auctions, placing sponsored firms at the top of search rankings, to steer consumers towards specific businesses. In addition to monetary instruments, platforms also leverage non-monetary practices to enhance visibility or facilitate product comparisons. For instance, online marketplaces can adjust the information presented on product pages, offering more informative attributes for favored items and more dispersed information on the webpage of the rival. Another method consists of prominently displaying an alternative favored product on the webpage of competing products while not providing a similarly prominent alternative on the favored item's page. These practices are observable, for instance, in Amazon's marketplace. The platform may provide informative details for particular products or position a favored product directly beneath the description of a similar product the consumer is browsing. These actions introduce unequal market treatment, influencing consumers' perceptions and purchasing decisions.

This paper analyzes how an intermediary affects competition among firms, consumer surplus, and total welfare by introducing an instrument that influences consumers' perceptions of product differentiation between firms. We rely on the model proposed by Hotelling (1929), where two firms are located at the extremes of consumers' taste distribution, and we assume linear transportation costs. The intermediary has the ability to manipulate the relative differentiation between the two firms by simultaneously reducing the transportation cost for the prominent firm and increasing it for its rival by an equal amount, thereby maintaining the average transportation cost at a constant level. This type of steering instrument resembles the examples mentioned earlier, where the amount of information, or the prominent display, enhances the accessibility of the favored firm while simultaneously lowering the accessibility of the rival.

Interestingly, the asymmetric treatment can increase total industry profit and consumer surplus. Compared to a scenario with symmetric treatment, the favored firm can considerably expand its reach as most consumers benefit from reduced transportation costs. However, the asymmetric treatment also enables the favored firm to raise its price, extracting more consumer surplus. In

contrast, the rival firm is compelled to adopt a more aggressive pricing strategy to avoid a significant loss of demand. Consumers closer to the location of the less accessible firm benefit from the lowered price, although they incur larger transportation costs. The overall impact on consumers is positive and becomes more significant as the relative differentiation introduced by the intermediary increases. For the firms, the gains of the favored firm outweigh the losses incurred by the competitor.

The findings of this paper suggest that striving for a perfect level playing field in the online economy may only sometimes be advisable.[1] The use of non-pricing instruments that steer consumers' consumption choice can benefit both the industry and consumers. However, these results may not hold when firms can pay to gain prominence, as advertising costs can be passed on to consumers through higher prices or lower product quality. These paying-for-prominence practices are extensively used in online marketplaces, and digital advertising represents a significant share of platforms' revenues.

Digital advertising is a rapidly growing sector, with significant investments made in this area. In the European Economic Area (EEA), for example, €46 billion was spent on digital advertising in 2021, surpassing expenditures on all other advertising channels combined (European Commission, 2023). Concerns have been raised regarding the impact of advertised online products, which are often found to be more expensive and of lower quality compared to their competitors.[2] In an extension of our analysis, we explore the relationship between advertising and product quality, and we demonstrate that there is potential for steered consumers to benefit from higher-quality advertised products.

The paper is structured as follows. Section 2.2 reviews the literature on Hotelling models with asymmetric transportation costs and highlights our contributions. Section 2.3 presents the model and the analysis. Section 2.4 presents an extension in which we analyze how asymmetric transportation costs affect quality investments. Finally, Section 2.5 summarizes our findings and concludes with implications for policy and managerial decisions.

[1]The European Commission states that one of the two main goals of the two new regulations, the Digital Service Act and the Digital Market Act, is to *"to establish a level playing field to foster innovation, growth, and competitiveness"* (https://digital-strategy.ec.europa.eu/en/policies/digital-services-act-package).

[2]Recently, Mustri et al. (2022) show through experiments that behavioral advertising may harm consumers. Exposure to targeted advertising can lead consumers to often encounter lower-quality products with higher prices.

2.2 Related Literature

Our paper builds upon the existing literature on product differentiation, persuasive advertising, and prominence.

Regarding modelization, the closest work to ours is Dos Santos Ferreira and Thisse (1996), which studies and extends the model proposed by Launhardt (1885). This model focuses on the role of asymmetric transportation costs rather than firms' location choices, as in the classic Hotelling model. Dos Santos Ferreira and Thisse (1996) demonstrate that the Hotelling model can be viewed as a particular case of the Launhardt model. They extend the model by allowing firms to strategically choose their transportation costs, treating them as a proxy for quality, where lower costs indicate higher quality. In equilibrium, when firms are located at the endpoints of the market segment, they choose to set the same (high) transportation rate to maximize total differentiation. The main difference with our study is that we do not allow firms to set their transportation costs optimally; instead, the intermediary introduces and optimizes the asymmetry. This difference enables us to examine how the asymmetry generates more value in the market and its potential to benefit both the industry and consumers.

The studies by von der Fehr and Stevik (1998) and Bloch and Manceau (1999) provide valuable insights into the effects of persuasive advertising on competition among firms within the framework of the Hotelling model. von der Fehr and Stevik (1998) explore various ways advertising can impact consumers' preferences. One specific aspect they consider is advertising as a tool to increase perceived product differences. By altering the slope of consumers' willingness-to-pay (WTP) functions, advertising can make the functions steeper. As the intensity of advertising increases, the WTP functions become even steeper, bringing firms closer to local monopolies. Bloch and Manceau (1999) focus on persuasive advertising as a means for firms to modify the taste distribution of consumers in favor of one particular product. They show that a multiproduct monopolist can benefit from persuasive advertising if it allows concentrating the market around one product. Instead, in a duopoly, advertising may intensify price competition and, therefore, it may be unprofitable for firms to engage in persuasive advertising. In other words, firms prefer a more uniform distribution of consumers' tastes. Similarly to von der Fehr and Stevik (1998), and in contrast with Bloch and Manceau (1999), in our study, the asymmetric

treatment introduced by the intermediary alters consumers' perception of differentiation between products rather than changing the consumers' taste distribution. However, in our model, the treatment reduces the transportation cost for the favored firm while increasing it for its rival by the same magnitude. As a result, the slope of the willingness-to-pay function for the less accessible firm is steeper, while the slope of the willingness-to-pay function of the favored rival is flatter. This difference in steepness induces firms to react in opposite ways. The favored firm exploits the greater reach by increasing its price, extracting a higher surplus. The rival, instead, counterbalances its lower accessibility by pricing more aggressively.

The extension on quality investment in our analysis is closely related to the literature that examines the interaction between competition with differentiated products and the supply of quality. Prior research, such as the study by Ma and Burgess Jr (1993), has shown that prices and qualities act as strategic substitutes, resulting in a suboptimal level of quality firms provide. The authors suggest that regulating prices can help restore efficiency in quality provision. In contrast, our analysis reveals a different finding. We demonstrate that the favored firm tends to deliver more quality as relative differentiation increases. The combination of higher quality and lower transportation costs allows the favored firm to reach a larger consumer base. Despite the higher prices associated with higher quality, the overall effect on consumers is positive.

Our analysis is also connected to the prominence literature in which intermediaries assign prominence to firms via monetary instruments (Armstrong and Zhou, 2011; Teh and Wright, 2022), more recently via non-monetary instruments (Ciotti and Madio, 2023; Bar-Isaac and Shelegia, 2022), and to the biased steering literature (de Cornière and Taylor, 2019; Bourreau and Gaudin, 2022). It is also worth mentioning another related recent work by Johnen and Leung (2022), which studies how firms strategically design the information they provide to consumers. The latter have limited attention, and their browsing and purchasing decisions are guided by the type of information they observe.

In the next section, we analyze the model by introducing asymmetric transportation costs. Then, we evaluate the impact on market outcomes of the asymmetric treatment by comparing the results with the symmetric scenario. Finally, we examine the possibility of the intermediary to monetize the asymmetric treatment and optimize relative differentiation.

2.3 The Model

The symmetric case. There are two firms, 1 and 2, located respectively at 0 and 1 on the Hotelling line measuring consumers' tastes, with marginal costs of production normalized to 0. There is a mass 1 of consumers uniformly distributed between 0 and 1. They incur a transportation cost τ per unit of distance to purchase one good. The utilities associated with the purchase of a good from firm 1 or 2 of a consumer located at x are:

$$u_1(p_1) = v - p_1 - \tau x, \qquad u_2(p_2) = v - p_2 - \tau(1-x),$$

where v is the common valuation of the good, p_i is the price set by firm i, and x is the preferred location of the consumer. The firms' profit functions are:

$$\pi_1(p_1, p_2) = D_1(p_1, p_2)p_1, \qquad \pi_2(p_2, p_1) = D_2(p_2, p_1)p_2,$$

where $D_i(p_i, p_{-i})$ is the demand captured by firm i. Firms set prices simultaneously, and we assume they fully cover the market such that $D_1(p_1, p_2) + D_2(p_2, p_1) = 1$. We define the demands by determining the marginal consumer, i.e., the consumer who is indifferent between purchasing the good from firm 1 or 2. We equalize the utilities and obtain the indifferent consumer:

$$\hat{x} = \frac{p_2 - p_1 + \tau}{2\tau}.$$

Demand of firm 1 is $D_1(p_1, p_2) = \hat{x}$, and demand of firm 2 is $D_2(p_2, p_1) = 1 - \hat{x}$. The analysis is standard. We have that firms set prices $p_1 = p_2 = \tau$, the indifferent consumer $\hat{x}$ is located at $1/2$, and the equilibrium profits are $\pi_1 = \pi_2 = \tau/2$. The condition that ensures full market coverage is $v \geq 3\tau/2$, and total industry profit, consumer surplus, and welfare are, respectively:

$$\begin{aligned} TI =& \pi_1 + \pi_2 = \tau, \\ CS =& \int_0^{\hat{x}} u_1 \, dx + \int_{\hat{x}}^1 u_2 \, dx = v - \frac{5\tau}{4}, \\ W =& TI + CS = v - \frac{\tau}{4}. \end{aligned}$$

As it is commonly observed, industry profit is increasing while consumer surplus and welfare are decreasing in total differentiation.

The asymmetric case. We now assume that transportation costs are asymmetric (i.e., $\tau_1 \neq \tau_2$), and that the platform favors firm 2. Consumers purchasing from firm 1 incur an additional transportation cost of $\Delta > 0$, while consumers buying from firm 2 benefit from an equivalent reduction in transportation cost. Specifically:

$$\tau_1 = \tau + \Delta, \qquad \tau_2 = \tau - \Delta.$$

Therefore, Δ represents a measure of relative differentiation, or in other words, the degree of asymmetry between firms. To maintain a constant average transportation cost, we ensure that the asymmetrical treatment is of equal magnitude.[3] This asymmetry is akin to the examples we discussed in the introduction. For example, the platform can favor one firm by placing a direct link to a competing product's webpage right beneath the item's description. However, the opposite is not done on the webpage of the favored firm's product, as no alternative link is provided. In addition, we assume that $\tau > \Delta > 0$ as a negative transportation cost for the favored firm would not make sense.

In this scenario, the indifferent consumer is $\hat{x} = (p_2 - p_1 + \tau - \Delta)/2\tau$, and the best replies are:

$$p_1 = \frac{p_2 + \tau - \Delta}{2}, \qquad p_2 = \frac{p_1 + \tau + \Delta}{2},$$

Having determined the best replies, we can now identify the equilibrium prices:

$$p_1 = \tau - \frac{\Delta}{3}, \qquad p_2 = \tau + \frac{\Delta}{3},$$

the equilibrium demands:

$$D_1 = \frac{1}{2} - \frac{\Delta}{6\tau}, \qquad D_2 = \frac{1}{2} + \frac{\Delta}{6\tau},$$

and the associated equilibrium profits:

$$\pi_1 = \frac{(\Delta - 3\tau)^2}{18\tau}, \qquad \pi_2 = \frac{(\Delta + 3\tau)^2}{18\tau}.$$

[3] An alternative approach would be to reduce the transportation cost of firm 2 without altering the cost of firm 1 (i.e., $\tau_1 = \tau$ and $\tau_2 = \tau - \Delta$). However, this measure artificially decreases overall differentiation in the market, intensifying competition between the firms. Conversely, increasing the transportation cost of firm 1 while keeping firm 2's costs unchanged (i.e., $\tau_1 = \tau + \Delta$ and $\tau_2 = \tau$) enhances total differentiation and reduces competition intensity. Hence, to avoid confounding effects arising from changes in total differentiation, it is crucial for the asymmetric treatment to serve as a mean-preserving spread.

To ensure full market coverage, we need to assume that the common valuation of the goods is large enough, i.e. $v \geq (9\tau^2 - \Delta^2)/6\tau$.[4]

By observing the best replies, we notice that prices are strategic complements and increase as total differentiation grows. These responses align with the classic result that higher differentiation relaxes competition. However, the asymmetric treatment makes the firms react in opposite directions when relative differentiation increases. Indeed, firm 1 prices more aggressively, while firm 2 raises its price. This phenomenon occurs because an increase in relative differentiation leads to a higher portion of demand attracted by firm 2 as its product is associated with lower transportation costs. Then, firm 2 can increase its price without fearing losing too much demand. In contrast, firm 1 needs to lower its price to mitigate the demand loss. Finally, we note that the difference in profit is also increasing in Δ:

$$\pi_2 - \pi_1 = \frac{2}{3}\Delta.$$

We now derive the total industry profit, consumer surplus, and welfare. The total industry profit is:

$$TI = \pi_2 + \pi_1 = \tau + \frac{\Delta^2}{9\tau},$$

and we can observe that it is increasing both in total and relative differentiation. Consumer surplus is:

$$CS = \int_0^{\hat{x}} u_1 \, dx + \int_{\hat{x}}^1 u_2 \, dx = v - \frac{5\tau}{4} + \frac{\Delta^2}{36\tau},$$

which is decreasing in total differentiation but increasing in Δ. Finally, we can derive welfare:

$$W = TI + CS = v - \frac{\tau}{4} + \frac{5\Delta^2}{36\tau},$$

which is also increasing in relative differentiation and decreasing in τ.

[4]Note that the condition in the asymmetric case is less constraining than in the symmetric setting. This result implies that if we assume market coverage in the symmetric case, the market remains covered in the asymmetric scenario as we increase Δ (that is, as the market becomes more asymmetric). Technically speaking, this is because the utility of the indifferent consumer increases as the asymmetry increases. As Δ increases, the two components of the generalized price that this consumer pays (price and transportation cost) move in opposite directions. Either (for good 1) the equilibrium price decreases more than the transportation costs increase. Or (for good 2), the equilibrium price increases less than the transportation costs decrease.

Comparing the two cases. Now, we analyze the impact of introducing transportation cost asymmetries compared to the symmetric Hotelling setting. To facilitate the notation, we identify the variables of the symmetric setting with the superscript 's'. We first compare the consumer surplus and observe that asymmetric treatment benefits consumers:

$$CS - CS^s = \frac{\Delta^2}{36\tau} > 0,$$

In Figure 2.1, we depict the two scenarios and analyze the impact of asymmetric treatment on consumer surplus. The willingness-to-pay functions of the symmetric case are shown in black, while those from the asymmetric situation are presented in orange. By examining the gains (in light blue) and the losses (in light orange) experienced by consumers, it becomes evident that the sum of the light blue regions exceeds that of the light orange areas. Consumers situated closer to the 0 derive greater utility due to the reduced prices set by firm 1 in response to the asymmetrical treatment. Conversely, a small portion located near $\hat{x}$ experiences a decline in utility since these consumers continue to purchase from firm 1 but face increased transportation costs. Instead, consumers close to 1 face a disadvantage as they bear the higher price firm 2 sets, enabled by the asymmetric treatment. However, a considerable segment of consumers near $\hat{x}$ benefits from reduced transportation costs. It is worth noting that the intersection of the willingness-to-pay functions of the asymmetric and symmetric cases occurs at 1/3 for firm 1 and 2/3 for firm 2. The intersections do not depend on the value of Δ and essentially represent the minimum levels of demand that firms can secure for any $\tau \geq \Delta$.

Looking now at the firms' profits, we observe that, for any $\tau > \Delta$, the asymmetric treatment rewards firm 2 and penalizes firm 1:

$$\pi_1 - \pi_1^s = \frac{\Delta(\Delta - 6\tau)}{18\tau} < 0, \qquad \pi_2 - \pi_2^s = \frac{\Delta(\Delta + 6\tau)}{18\tau} > 0.$$

Surprisingly, introducing the asymmetric treatment enables firms to generate greater value in the market jointly. This is because the losses of firm 1 are more than compensated by the gains of firm 2. The asymmetric treatment allows firm 2 to reach most consumers, who benefit from reduced transportation costs, increasing their utility for a given price. The lower transportation costs allow firm 2 to extract higher value from most consumers. On the other hand, firm 1 not only cedes a significant share of its consumer base to its competitor but also

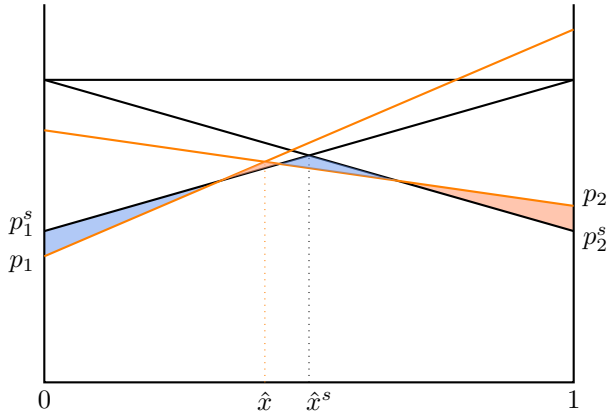


Figure 2.1. Comparison between the symmetric and the asymmetric cases: consumer surplus ($\tau = 1/2$, $\Delta = 1/4$).

finds itself compelled to adopt more competitive pricing strategies in response to the elevated transportation costs borne by its consumers. Consequently, firm 1 experiences an overall negative impact. However, in terms of total industry profit, the overall effect of the asymmetric treatment is positive:

$$TI - TI^s = \frac{\Delta^2}{9\tau} > 0.$$

Ultimately, overall welfare also increases:

$$W - W^s = \frac{\Delta^2}{36\tau} > 0.$$

We summarize the findings with the following.

Proposition 6. *The introduction of asymmetric transportation costs provides overall benefits to the marketplace economy, albeit at the expense of the disadvantaged firm.*

2.3.1 Monetizing the intermediary's service

In this section, we examine the interests and monetization methods of the intermediary. While the intermediary's intervention creates additional value, it also provides monetization opportunities akin to methods like advertising or sponsorship. We will study the possible monetization methods that can be employed by the intermediary and analyze their impact on market outcomes.[5] We will also explore the intermediary's ability to choose the intensity of relative differentiation under each monetization scheme. In this section, we assume that the intermediary incurs no cost in introducing the asymmetric treatment and that it sets the fee before the price competition stage.[6]

Lump sum fee. Assume that, before the pricing stage, the intermediary requires an incentive-compatible lump sum payment L in exchange for the advertising. Then, the intermediary's profit would be equal to:

$$\Pi^L = L = \pi_2 - \pi_2^s = \frac{\Delta(6\tau + \Delta)}{18\tau},$$

By differentiating the intermediary's profit with respect to the intensity of relative differentiation, we can observe that the intermediary's profit is linear and increasing in Δ:

$$\frac{\partial L}{\partial \Delta} = \frac{1}{9}\left(\frac{\Delta}{\tau} + 3\right) > 0.$$

Therefore, the optimal intensity of relative differentiation is the maximum value the intermediary can set, i.e., $\Delta = \tau$. Then:

$$\Pi^L = \frac{7\tau}{18}.$$

We note that an alternative approach, wherein the intermediary obtains a share of the profits from the advertised firm, would result in an equivalent profit for the intermediary. This outcome is a direct consequence of the assumptions made so far.

[5] It is important to note that we do not consider monetization methods on the demand side of the intermediary, as we assume fixed demand and full market coverage. Therefore, any monetization strategies would not affect consumers' entry decisions.

[6] Online platforms bear no (or negligible) cost in giving prominence to a firm or changing the amount or the quality of the information provided on the product's webpage.

Per unit fee. Under the per unit fee scheme, the intermediary requires a fee from the advertised firm for each unit sold. The firms' profit functions, in this case, are $\pi_1^f = D_1 p_1$ and $\pi_2^f = D_2(p_2 - f)$, where $f > 0$ represents the per unit fee imposed by the intermediary. In equilibrium, the prices incorporate the fee that needs to be paid to the intermediary:

$$p_1^f = \frac{f + 3\tau - \Delta}{3}, \qquad p_2^f = \frac{2f + 3\tau + \Delta}{3},$$

and the indifferent consumer is located at $(f + 3\tau - \Delta)/6\tau$. The firms' equilibrium profits are:

$$\pi_1^f = \frac{(3\tau - \Delta + f)^2}{18\tau}, \qquad \pi_2^f = \frac{(3\tau + \Delta - f)^2}{18\tau},$$

and the profit of the intermediary is given by:

$$\Pi^f = f D_2 = \frac{f(3\tau + \Delta - f)}{6\tau}.$$

To ensure full market coverage, we need the following conditions to be verified: $f < 3\tau$ and $v > [(f + 3\tau - \Delta)(3\tau + \Delta)]/6\tau$. If the intermediary were to set the fee to maximize its profit optimally, it would choose $f = (3\tau + \Delta)/2$; however, this fee is not incentive-compatible as $\pi_2^f - \pi_2^s = (\Delta + 6\tau\Delta - 27\tau)/72\tau < 0$. Hence, the highest fee the intermediary can set is the incentive-compatible one that solves $\pi_2 = \pi_2^s$. We find two possible values, $f = \Delta$ and $f = 6\tau + \Delta$. The second fee violates the full market coverage conditions. Thus, the chosen fee is $f = \Delta$,[7] and the profit of the intermediary is:

$$\Pi^f = \frac{\Delta}{2}.$$

In this case, the intermediary is also interested in setting the maximum value of Δ. Hence:

$$\Pi^f = \frac{\tau}{2}.$$

[7] We must note that to compare this scenario with the symmetric one, the per unit fee we identified may violate the market coverage condition found in the symmetric case. Indeed:

$$v \geq \frac{3\tau + \Delta}{2} > \frac{3\tau}{2}.$$

Therefore, during our comparisons, we need to assume that $v \geq (3\tau + \Delta)/2$ across all scenarios. Otherwise, there could be a situation in which the fee pushes some consumers out of the market, and two local monopolies arise.

Comparison. Comparing the lump sum fee scenario with the per unit fee scenario, we find that the per unit fee grants higher returns to the intermediary. Specifically:

$$\Pi^L = \frac{7\tau}{18} < \frac{\tau}{2} = \Pi^f.$$

This result is slightly surprising as we could expect the per unit scenario to suffer from a double marginalization problem. Moreover, the per unit fee set by the intermediary is sub-optimal, as the fee set is determined by solving the incentive-compatibility constraint. However, the double marginalization problem is mitigated by the market coverage assumption and the fixed demand, which does not allow us to take into account the effects on the extensive margin. Interestingly, the per unit fee allows the intermediary to restore symmetry in the market:

$$\pi_1^f = \pi_1^s, \qquad \pi_2^f = \pi_2^s$$

and $\hat{x}^f = 1/2$. The intermediary appropriates the extra value created by the asymmetric treatment, and the entire cost is passed on to the consumers:

$$CS^f = v - \frac{7\tau}{4} < v - \frac{5\tau}{4} = CS^s.$$

Consequently, consumers are worse off than in the symmetric case, and firms' profit remains unchanged. On the other hand, consumers benefit from the asymmetry in the lump sum fee scenario, as the industry bears the cost of the advertising service:

$$CS^L = v - \frac{11\tau}{9} > v - \frac{5\tau}{4} = CS^s, \qquad TI^L = \frac{13\tau}{18} < \tau = TI^s.$$

We summarize the findings as follows

Proposition 7. *Depending on the monetization strategy of the intermediary, the asymmetric treatment may not be beneficial for consumers. The preferred fee scheme of the intermediary is imposing a per unit fee, which restores symmetry and makes consumers worse off. Instead, if the intermediary employed a lump sum fee, consumers would be better off as the industry would bear the total cost of the service.*

2.4 Quality investment

In this section, we extend the baseline model by incorporating the impact of asymmetric transportation costs on the supply of quality q_i. We assume that consumers have a positive valuation for quality and firms can invest in costly quality. Additionally, we modify the timing of the game, with quality decisions taking place in the first stage, followed by price determination in the second stage.

In this extension, the utilities are:

$$u_1 = v + q_1 - p_1 - \tau_1 x, \qquad u_2 = v + q_2 - p_2 - \tau_2(1-x),$$

and the firms' profit functions are:

$$\pi_1 = D_1 p_1 - \gamma \frac{q_1^2}{2}, \qquad \pi_2 = D_2 p_2 - \gamma \frac{q_2^2}{2},$$

where the right-hand side of the profit functions represents the cost of investing in a unit of quality, with $\gamma > 0$. We follow the same structure seen in Section 2.3.

The symmetric case. We start by setting $\tau_1 = \tau_2 = \tau$ and deriving the demands of the firms by determining the marginal consumer $\hat{x} = (p_2 - p_1 + q_1 - q_2 + \tau)/2\tau$. In the second stage, firms set prices simultaneously. The reaction functions are:

$$p_1 = \frac{1}{2}(p_2 + q_1 - q_2 + \tau), \qquad p_2 = \frac{1}{2}(p_1 - q_1 + q_2 + \tau),$$

which allows us to derive the equilibrium prices:

$$p_1 = \frac{q_1 - q_2}{3} + \tau, \qquad p_2 = \frac{q_2 - q_1}{3} + \tau.$$

Then, in the first stage, firms set qualities simultaneously. The reaction functions are:

$$q_1 = \frac{q_2 - 3\tau}{1 - 9\gamma\tau}, \qquad q_2 = \frac{q_1 - 3\tau}{1 - 9\gamma\tau},$$

which allow us to derive the equilibrium qualities:

$$q_1 = \frac{1}{3\gamma}, \qquad q_2 = \frac{1}{3\gamma}.$$

The conditions we need to ensure full market coverage are $v > (9\gamma\tau - 2)/6\gamma$ and $\gamma > 2/9\tau$. Finally, we derive the consumer surplus:

$$CS = \int_0^{\hat{x}} u_1 \, dx + \int_{\hat{x}}^1 u_2 \, dx = v + \frac{1}{3\gamma} - \frac{5\tau}{4}.$$

The asymmetric case. Assume now that $\tau_1 = \tau + \Delta$ and $\tau_2 = \tau - \Delta$. Therefore, the indifferent consumer is now located at $(p_2 - p_1 + q_1 - q_2 + \tau - \Delta)/2\tau$. In the second stage, firms set prices simultaneously and the equilibrium prices are:

$$p_1 = \frac{q_1 - q_2 + 3\tau - \Delta}{3}, \qquad p_2 = \frac{q_2 - q_1 + 3\tau + \Delta}{3}.$$

In the first stage, firms set qualities simultaneously and the equilibrium qualities are:

$$q_1 = \frac{1}{3\gamma} - \frac{\Delta}{9\gamma\tau - 2}, \qquad q_2 = \frac{1}{3\gamma} + \frac{\Delta}{9\gamma\tau - 2}.$$

Then, we can derive the equilibrium demands:

$$D_1 = \frac{1}{2} - \frac{\Delta}{6\tau}, \qquad D_2 = \frac{1}{2} + \frac{\Delta}{6\tau},$$

and profits:

$$\pi_1 = \frac{(\Delta - 3\tau)^2}{18\tau}, \qquad \pi_2 = \frac{(\Delta + 3\tau)^2}{18\tau}.$$

The conditions we need to ensure market coverage in the asymmetric case and allow us to compare the two settings are $v > (9\gamma\tau - 2)/6\gamma$ and $\gamma > 2/(9\tau - 3\Delta)$.[8] Similarly to the analysis in Section 2.3, it is possible to observe that the larger the relative differentiation, the larger is the demand captured by firm 2, and the larger the difference in prices and qualities between the two firms. Moreover, increasing relative differentiation lowers the profit of firm 1 while increasing the profit of firm 2:

$$\frac{\partial \pi_1}{\partial \Delta} = -\frac{(9\gamma\tau - 1)(9\gamma\tau - 3\gamma\Delta - 2)}{3(2 - 9\gamma\tau)^2} < 0,$$
$$\frac{\partial \pi_2}{\partial \Delta} = \frac{(9\gamma\tau - 1)(3\gamma(3\tau + \Delta) - 2)}{3(2 - 9\gamma\tau)^2} > 0.$$

Finally, we derive the consumer surplus:

$$\begin{aligned} CS &= \int_0^{\hat{x}} u_1 \, dx + \int_{\hat{x}}^1 u_2 \, dx \\ &= \frac{3\gamma\left(\tau\left(9\gamma\left(-45\gamma\tau^2 + g\Delta^2 + 32\tau\right) - 68\right) + 4v(2 - 9\gamma\tau)^2\right) + 16}{12\gamma(2 - 9\gamma\tau)^2}. \end{aligned}$$

[8] Compared to the symmetric case, we need a stronger constraint on γ. If quality investment costs are sufficiently low, there might be cases where the favored firm is worse off than the rival.

Comparison. We now analyze how asymmetric transportation cost affects quality decisions. To simplify the notation, we denote the variables in the symmetric setting with the superscript 's'. In equilibrium, the asymmetry leads firm 1 to reduce both its price and quality. Conversely, firm 2 experiences an increase in both price and quality compared to the symmetric case:

$$p_1 = \frac{3\gamma\tau\Delta}{2-9\gamma\tau} + \tau < \tau = p_1^s, \qquad p_2 = \frac{3\gamma\tau\Delta}{9\gamma\tau-2} + \tau > \tau = p_2^s,$$
$$q_1 = \frac{1}{3\gamma} - \frac{\Delta}{9\gamma\tau-2} < \frac{1}{3\gamma} = q_1^s, \qquad q_2 = \frac{1}{3\gamma} + \frac{\Delta}{9\gamma\tau-2} > \frac{1}{3\gamma} = q_2^s.$$

The total quality level supplied in the market remains unchanged:

$$q_1 + q_2 = \frac{2}{3\gamma} = q_1^s + q_2^s.$$

However, the consumption of quality is higher in the asymmetric case:

$$q_1\ \hat{x} + q_2(1-\hat{x}) = \frac{3\gamma\Delta^2}{(2-9\gamma\tau)^2} + \frac{1}{3g} > \frac{1}{3\gamma} = q_1^s\hat{x}^s + q_2^s(1-\hat{x}^s).$$

Due to the combination of lower transportation costs and higher quality, the favored firm gains a competitive advantage and is able to reach a larger share of consumers despite charging a higher price. As a result, most consumers purchase the higher-quality product the favored firm offers. On the other hand, the rival serves the remaining market segment, offering its product at a lower price but with lower quality. Finally, by comparing the consumer surplus in the two scenarios, we observe that:

$$CS - CS^s = \frac{9\gamma^2\tau\Delta^2}{4(2-9\gamma\tau)^2} > 0.$$

which is always positive.

Proposition 8. *The introduction of asymmetric transportation costs positively impacts consumers as most purchase from the favored firm and benefit from lower transportation costs and higher product quality despite higher prices.*

2.5 Conclusion

In this study, we investigated the manipulation of consumers' perception of differentiation between two firms by an intermediary. The intermediary can reduce transportation costs for one firm while increasing them for its rival. As a result, the favored firm gains a competitive advantage by reaching customers more easily along the Hotelling line, also allowing it to increase its prices. Conversely, the rival firm adopts more competitive pricing strategies to avoid losing significant demand. The interaction between asymmetric transportation costs and price adjustments can benefit consumers. However, we also highlight that an intermediary could monetize its asymmetric treatment in a manner that adversely affects consumer welfare compared to a symmetric scenario. Therefore, our findings suggest that potential public interventions in the interests of consumers should focus more on the business model employed by the intermediary rather than solely aiming for a level playing field. It is important to note that while our stylized model uncovers certain positive effects of introducing asymmetric treatments in the marketplace, it does not consider the effects of such an instrument on changes in demand, which can have significant implications.

3

Lock-in Effects in Online Labor Markets

Co-authored with Lars Hornuf and Eliza Stenzhorn.

Online platforms that implement reputation mechanisms usually prevent the transfer of ratings to other platforms, leading to lock-in effects and high switching costs for users. This situation can be capitalized by platforms, for example, by charging their users higher fees. In this paper, we theoretically and experimentally investigate the effects of platform pricing on workers' switching behavior in online labor markets and analyze whether a policy regime with reputation portability could mitigate lock-in effects and reduce the likelihood of worker capitalization by the platform. We further examine switching motives more thoroughly and differentiate between monetary motives and fairness preferences. Theoretically, we provide evidence for the existence of switching costs if reputation mechanisms are platform-specific. The model predicts that reputation portability lowers switching costs, eliminating the possibility for platforms to capitalize lock-in effects. We test our predictions using an online lab-in-the-field experiment. The results are in line with our theoretical model and show that the absence of reputation portability leads to worker lock-in, which can be capitalized by platforms. Moreover, reputation portability has a positive impact on the wages of highly rated workers. The data further show that the switching of workers is primarily driven by monetary motives, but perceiving the platform fee as unfair also plays a significant role for workers.

3.1 Introduction

Most online marketplaces use reputation mechanisms to facilitate transactions between users. Reputation mechanisms build trust and address market inefficiencies that arise from asymmetric information (Dellarocas et al., 2006; Kokkodis and Ipeirotis, 2016). However, many platforms employ platform-specific reputation mechanisms and do not allow users to transfer their ratings to other platforms. Because ratings have an economic value (Resnick et al., 2006; Saeedi, 2019), platform-specific ratings can create lock-in effects and in turn cause high switching costs, which can make users more vulnerable to platform exploitation (Choudary, 2018). To this day we know little about how users react when platforms capitalize on these lock-in effects. In this paper, we therefore experimentally examine user reactions to a platform fee and examine what motivates users to switch to another platform after a fee is introduced. Moreover, we study the effect of reputation portability and ratings on workers' switching behavior, performance, and wages earned.

The presence of switching costs is not necessarily welfare decreasing for users. If users face switching costs, firms then may engage in fierce ex-ante competition to gain market shares, and relax competition ex-post, once users are locked-in (Klemperer, 1987a,b, 1995; Farrell and Shapiro, 1988, 1989). The resulting welfare effect is ambiguous and may or may not be detrimental to users. Policy interventions, such as the European Union's (EU) Digital Market Act, suggest that ex-ante competition may not offset the negative ex-post effects on welfare. Possibly, the presence of dominant platforms may exacerbate the negative impacts of lock-in effects because these platforms do not need to compete much for new users. Thus, dominant platforms are able to increase

Author's statement: Fabrizio Ciotti's roles in the project included methodology development, conceptualizing the study, validation, writing of original drafts, review/editing, and visualization of data. Lars Hornuf was supervising the project. He managed project administration, acquiring funding, allocating resources, conceptualizing the study, methodology development, validation, and writing review/editing. Eliza Stenzhorn's responsibilities encompassed conceptualization of the research, methodology development, software programming, validation of results, formal data analysis, investigation, data curation, writing original drafts, review/editing, and visualization of findings. The data supporting this study's findings are available from the corresponding author (Eliza Stenzhorn) on request.

and sustain high fees over time, capitalizing on locked-in users.[1]

Hereinafter, we use a combination of a theoretical model and an experimental analysis to investigate the effects of a platform fee on workers' switching behavior in online labor markets in two policy regimes: a regime without reputation portability—the status quo—and a regime with reputation portability, which could be mandated by regulation. In the second policy scenario, we imagine a case with reputation portability, in which platforms import workers' ratings when they switch. In practical terms, we consider the case where reputation data is entirely and automatically exported from one platform to another.[2] Our focus is on online labor markets, in particular microtask platforms. These platforms are generally used to hire workers to perform small and repetitive tasks that are labor intensive (Durward et al., 2020). Especially on microtask platforms, workers rely heavily on their reputation scores and lack the opportunity to multi-home in the presence of platform-specific reputation mechanisms. Workers on microtasking platforms are typically classified as independent contractors (Prassl and Risak, 2015) and research suggests that these workers may also face precarious working conditions, amongst others, in the form of insecure and low earnings (Berg et al., 2018; Hornuf and Vrankar, 2022).

Our theoretical framework represents a variation of Holmström's (1999) model of managerial incentives. In this model, workers care about their future reputation and must choose the optimal effort to exert when completing a task. We extend Holmström's model by allowing workers to consider joining a different labor market platform. Switching costs arise when reputation mechanisms are platform-specific. These costs are defined as the effort investment that workers make over time to build their reputations and to maximize their revenue streams. Since the market is organized by a platform, we also introduce the possibility to impose a fee on workers' revenues and study the impact of a fee change in two policy regimes on reputation portability. We also consider more thoroughly *why* workers switch platforms, because different motives may have strong economic implications that are

[1] Apple's App Store, for example, takes a 30% commission on the total sale price of all paid apps (Kotapati et al., 2020).

[2] Reputation portability can be implemented via other designs as well. Another prominent example is the use of Personal Information Management Systems, which are supposed to provide users with a central online storage system to manage and share their personal data (Krämer, 2021). For a comprehensive description of different scenarios, see Hesse and Teubner (2019).

difficult to foresee. We distinguish two types of stylized workers: those with *monetary motives* and those who express *fairness preferences*. Workers with monetary motives are driven by the amount of their wages, while workers with fairness preferences have a preference for being treated fairly (Kahneman et al., 1986). Workers with fairness preferences care about the actions of the platform, such as the introduction of new fees. If they perceive unfair treatment, these workers may reciprocate by leaving the platform that levies a fee, even if doing so causes them to lose their ratings and, in turn, wages. In addition, workers with a preference for fairness may not only be less willing to pay a higher fee to stay on the platform, but may also perform worse after experiencing a fee (Fehr et al., 1993; Fehr and Falk, 1999), because their utility is lowered not only by the reduction in net wages, but also by the introduction of the fee itself. Thus, if fairness preferences are not taken into account, a fee increase could lower workers' effort more than expected and thus the overall appeal of the platform from a contractors' perspective.

Theoretically, we show that in a policy regime without reputation portability, the reputation investments of workers can become a switching cost. Moreover, even in the presence of an alternative platform offering better economic treatment, workers may refrain from switching because of their reluctance to lose their valuable ratings. However, our model predictions indicate that workers with fairness preferences are more susceptible to switch, compared to workers with pure monetary motives, because they face an additional disutility from the introduction of a fee. Instead, when reputation portability is enforced, workers do not incur switching costs and, thus, the fee they are willing to pay to stay in the platform is zero. Therefore, we expect that workers being treated with reputation portability will be more likely to switch and to avoid paying higher fees on the focal platform.

For our experimental evaluation, we conducted an online lab-in-the-field decision experiment with actual online workers from the crowdsourcing platform Amazon Mechanical Turk (AMT). This allows us to examine worker behavior in a natural work environment, and, at the same time, to study artificial policy changes and different levels of capitalization by platforms. In the experiment, participants are asked to work in a fictitious online labor market. Switching behavior is triggered by platforms charging fees. Our proposed design resembles an ultimatum game (Güth et al., 1982) in which a proposer (the platform), endowed with some good, must decide how to share it with a responder (the worker). The responder can decide to accept or

refuse the offer; if the responder refuses, both agents get nothing.

Experimentally, the results support the predictions from the theory model. The data show that a policy regime without reputation portability creates lock-in effects, which can be capitalized by the platform. In turn, a scenario with reputation portability significantly increases switching, such that workers are more likely to avoid paying higher fees. Furthermore, we evidence that switching behavior is driven by both monetary motives and fairness preferences. Workers expressing fairness preferences responded with lower performance after the introduction of a platform fee, even when they switched platforms. Finally, a policy regime with reputation portability has a positive impact on working conditions in terms of wages. By decreasing lock-in effects, the right to reputation portability, among other efforts, could help improve the position of online workers.

A key contribution of this paper is that we study not only the impact of a platform fee on switching behavior, but also workers' motivation to switch, and their performance after a fee is introduced. The study therefore has direct managerial implications with regards to platforms' business strategy, because it sheds light on the negative effect of capitalization of lock-in effects on workers' effort levels. Notably, our results may also be applicable to other online marketplaces where users rely on reputation, but reputation is not portable across platforms and multi-homing is difficult. For example, on e-commerce platforms like Amazon and eBay, the impact of platform fees on switching behavior could be similar for sellers in the policy regimes under consideration.

We further contribute to the current regulatory debate on data portability. To address lock-in effects and switching costs generated by data, regulators have already taken actions in the form of data privacy laws (Hesse and Teubner, 2019). The objective of such regulations is to both enhance data ownership and foster competition (Engels, 2016; De Hert et al., 2018). The most notable example is Article 20, the Right to Data Portability, of the European Union's General Data Protection Regulation (GDPR), which stresses that individuals have the right to request their own data, and transfer them to other online providers without difficulty.[3] According to current legal

[3]Other examples are the Californian Consumer Privacy Act of 2018, the Brazilian General Data Protection Law of 2020, the Swiss Federal Act on Data Protection of 2020, the German Act against Restraints of Competition for a focused, proactive and digital competition law 4.0 and amending other competition law provisions of 2021, and the Chinese Personal Information Protection Law of 2021.

interpretations, reputation data do not fall under the scope of Article 20 because ratings are provided by reviewers and not the user, such that a user does not legally own their reputation data (Graef et al., 2013; Diker Vanberg and Ünver, 2017). According to Kathuria and Lai (2018) and Hesse and Teubner (2019), reputation portability as outlined in Article 20 could help overcome lock-in effects and increase users' negotiation power.

However, further regulatory action may be necessary, because platforms do not naturally allow users to import or export their reputation data.[4] Although Amazon previously allowed sellers to import their reputation data from eBay, once eBay threatened to sue Amazon for intellectual property infringement, it halted this practice, which likely relaxed the competition for sellers (Resnick et al., 2000; Ba and Pavlou, 2002; Dellarocas et al., 2006). Still, it is technically feasible to transfer reputation data: when the dog sitting platform Rover merged with DogVacay, it gave DogVacay's users an easy path to transfer their ratings and transaction history to its platform (Farronato et al., 2020). Our study makes an important contribution to this debate by showing that reputation portability reduces lock-in effects of workers in online labor markets and also demonstrates the positive effects of a portability regime on workers' wages.

The remainder of the paper is organized as follows: In Section 3.2, we relate our research question to the existing literature. Section 3.3 contains our theoretical model and outlines our hypotheses. In Section 3.4, we detail our experimental setting and procedure. Section 3.5 describes the sample and summarizes the experimental results. Finally, Section 3.6 concludes the paper.

3.2 Related Literature

Related research can be divided into three categories: studies that investigate switching costs, studies that explore data portability, and studies that focus on online labor markets.

First, our paper is closely related to research studying switching costs (Klemperer, 1987a,b, 1995; Farrell and Shapiro, 1988, 1989). We follow Wohlfarth (2019) and assume that reputation portability, defined as the ability of users to transfer their reputation from one platform to another, determines the degree of switching costs and consequently the strength of

[4] As two exceptions that prove the rule, Bonanza.com and TrueGether.com allow users to import their ratings from other platforms (Hesse et al., 2020).

lock-in. Switching costs can result from investments in devices, learning or transaction costs, complementary services, or even psychological costs that reflect laziness, brand loyalty, and so forth (Farrell and Klemperer, 2007). When users confront high switching costs, they are unlikely to switch even if the focal platform becomes relatively more expensive than competitors. To the best of our knowledge, only one study experimentally investigates switching behavior while considering the strength of lock-in effects. Eurich and Burtscher (2014) conduct an online lab experiment with students to determine the consequences of changes in the business-to-consumer relationship. Increased prices, data leakages, and privacy violations can have negative consequences for the business and lead consumers to choose a competitor, despite the costs of switching. In our setting, online workers invest effort to increase their reputation over time, and because this reputation has significant economic value (Ba and Pavlou, 2002; Resnick et al., 2006; Moreno and Terwiesch, 2014; Luca, 2016; Saeedi, 2019), the workers are inclined to devote more effort to build a strong reputation and maintaining it over time (Fehr and Goette, 2007; Mason and Watts, 2009; Cabral and Xu, 2021). Our work is therefore complementary to the working paper by Eurich and Burtscher (2014), because it focuses on online workers' reputation formation and platform subscription choice, while at the same time studying possible lock-in capitalization by platforms.

Second, we provide insights into the debate on reputation portability and, more generally, data portability. To date, research has focused on the influence of reputation within an online platform, examining buyers willingness-to-pay for vintage postcards on eBay (Resnick et al., 2006) or the necessity of reputation mechanisms to provide category-specific feedback in online labor markets (Kokkodis and Ipeirotis, 2016). On the demand side of the market, reputation portability across task categories can help contractors make better hiring decisions (Kokkodis and Ipeirotis, 2016). In addition, a star rating on one platform can serve as an additional signal to build trust in service providers who have not yet received a rating on another platform (Otto et al., 2018), especially if the cross-platform signaling takes place in the same industry as the originating platform (Teubner et al., 2019; Hesse et al., 2020). With regards to the general idea of data portability between platforms, existing studies refer mostly to legal and technical dimensions (Dellarocas et al., 2006; Engels, 2016; De Hert et al., 2018; Krämer and Stüdlein, 2019; Wohlfarth, 2019).

Theoretical papers suggest that data portability generally has a positive effect on user welfare and can increase platform competition in online markets (Krämer and Stüdlein, 2019; Wohlfarth, 2019). However, data portability may also increase platforms' willingness to extract and disclose more data. Our study is conceptually different from all these previous works, because we analyze the supply side of online labor markets and consider lock-in capitalization by platforms and what would happen if reputation data of workers could be transferred across platforms. Thus far, none of these works studied the economic consequences of reputation portability on workers' surpluses. Hesse and Teubner (2019) provide a conceptualization and review of reputation portability that leads them to call for empirical and experimental studies to assess the economic value of cross-platform reputation mechanisms. Furthermore, existing literature on switching costs tends to assume scenarios with consumers being homogeneous with respect to their switching costs (Gehrig and Stenbacka, 2004). In reality, however, weak and high-performing users might suffer from lock-in differently and benefit differently from data portability rights. The Right to Data Portability under the GDPR has been in force since 2018, but so far there are only few empirical and theoretical studies on its economic consequences and none focuses on the consequences for online workers, which is also emphasized in an article by Krämer (2021), assessing the economic implications of Article 20 GDPR.

Finally, our paper also relates to the literature that focuses on online labor markets. Due to their monopsony power (Dube et al., 2020), online labor platforms can impose lock-in effects that limit the choice, mobility, and career development of workers, making them vulnerable and susceptible to capitalization. Choudary (2018) argues that the design of online labor platforms has important implications for whether its workers are empowered or exploited by the organizations. For example, providers with substantial market power might demand a higher percentage of workers' wages in return for providing the platform with their work (Kingsley et al., 2018). Some workers also confront unstable earnings, unpredictable scheduling, unclear employment status, and a lack of social protection or voice (Degryse, 2016; Berg et al., 2018; Johnston et al., 2018). Risks historically borne by employees in traditional employment relationships can be shifted to workers, who in turn earn less income than their counterparts in traditional employment relationships, at least in industrialized countries (Borchert et al., 2018; Hornuf and Vrankar, 2022). Wood et al. (2019) evaluate job quality in online labor markets and find that platforms' regulations often assign

autonomy to workers but at the cost of irregular working hours and strong competition, which creates downward pressure on their earnings. Gomez-Herrera et al. (2022) show that online labor markets can effectively impose higher fees on a portion of its workers without affecting labor demand or final prices. Workers are unable to pass on costs to contractors because they are competing with workers who are able to accept lower wages. The right to reputation portability, among other efforts, could help improve the position of online workers by decreasing their platform dependency. In an effort to understand switching behavior when lock-in effects are capitalized by platforms and to study the impact on reputation portability, we show that a policy regime with reputation portability can affect switching costs. Moreover, such a policy regime might not only reduce the likelihood of workers being capitalized by platforms, but also improve workers online working conditions in terms of higher wages.

3.3 Theoretical Framework

We first aim to derive formal, testable hypotheses. Second, we determine, with some simplifying assumptions, whether a platform can lock workers in using platform-specific reputation mechanisms, which in turn would enable it to capitalize locked-in workers. We propose a model based on Holmström (1999) that accounts for reputation formation for a representative worker, competing in an online labor market managed by a monopolist platform. Present performance provides relevant information about future performance, and an average rating achieved by a worker can invoke a premium or extra remuneration that the worker receives for each task, beyond any fixed wage. When workers first subscribe to the platform, they have no ratings. As they start working, they establish ratings that can change, according to their performance. A higher average rating should lead to higher wages. In other words, *ceteris paribus*, two workers who engage in the same level of labor might earn different wages if they have different average ratings.

Similar to Lambin and Palikot (2019), we consider ratings as a measure of the performance in every period t:

$$r_t = \eta + a_t + \epsilon_t, \quad t = 1, 2, ..., \tag{3.1}$$

where η is the worker's talent, which is fixed. The worker and the platform have incomplete information about the worker's talent and they

share a common prior belief about η. This prior belief is normally distributed, with mean m_1 and precision h_1, with precision being defined as the inverse of the variance. Over time, the demand side of the platform learns about the talent of the worker by observing the emerging rating r_t. The labor input of the worker is $a_t \in [0, \infty)$, and ϵ_t represents a stochastic noise term, normally distributed with mean zero and precision h_ϵ.

In every period t, the worker is paid according to the following revenue scheme:

$$c_t = f + w_t(\mathbf{r}_{t-1}), \tag{3.2}$$

where $f > 0$ is an exogenous fixed amount granted to workers who have completed a task, independently of their performance,[5] and $w_t(\mathbf{r}_{t-1})$ is the premium associated with the average of past ratings ($\mathbf{r}_{t-1} = r_0; ...; r_{t-1}$) received by a worker. We assume this information is known to the market and used as a basis for wage payments; it usually appears next to the agent's profile in practice, as a representation of past performance. Furthermore, we assume a competitive market and risk-neutral contractors (i.e., the demand side of the platform), who, upon posting the labor requests on the platform, set the premium in line with the average rating of the worker:

$$w_t(\mathbf{r}_{t-1}) = E[r_t|\mathbf{r}_{t-1}] = E[\eta|\mathbf{r}_{t-1}] + a_t(\mathbf{r}_{t-1}), \tag{3.3}$$

where $a_t(\mathbf{r}_{t-1})$ is the labor input, as the best response of the worker. Platforms act as intermediaries, and they charge an ad valorem fee, required after each transaction, for the intermediation service.[6] We assume this fee is applied directly to the workers' premium revenue. A worker's atemporal utility function is thus:

$$U(c, a, \phi) = \sum_{t=1}^{\infty} \beta^{t-1}[c_t - g(a_t)] - \sum_{t=k}^{\infty} \beta^{t-1}\phi c_t, \tag{3.4}$$

[5] Here, f does not affect the model results, because we assume the worker is risk neutral. We introduce this point in line with the experiment, in which we pay participants a minimum compensation.

[6] For example, Amazon marketplaces charges fees ranging from 7 to 45%, depending on the product category (https://sellercentral.amazon.com/help/hub/reference/external/200336920); Airbnb charges 3% (https://www.airbnb.com/help/article/1857); and online labor platforms such as AMT (https://www.mturk.com/pricing) and TaskRabbit (https://support.taskrabbit.com/hc/en-us/articles/204411610-What-s-the-TaskRabbit-Service-Fee-) charge 20% and 15%, respectively.

where $\beta \in [0,1]$ is a discount factor; $g(\cdot)$ is an increasing and convex function that represents the effort cost; and $U(\cdot,\cdot,\cdot)$ is publicly known. We assume that at time k, the platform increases its fee to $\phi \in [0,1]$,[7] and before k, the fee is normalized to 0.[8] The outside option for the worker is to not work, which provides utility equivalent to 0. Using Equations (3.2), and (3.4), we can write the problem of the worker for maximizing expected utility as follows:

$$\max_{a_{(\cdot)}} \sum_{t=1}^{\infty} \beta^{t-1}[f + Ew_t(\mathbf{r}_{t-1}) - Eg(a_t(\mathbf{r}_{t-1}))] - \sum_{t=k}^{\infty} \beta^{t-1}\phi[f + Ew_t(\mathbf{r}_{t-1})]. \quad (3.5)$$

The contractors cannot observe workers' labor input directly, but because Equation (3.4) is general knowledge, we can use it to infer a_t by solving the workers' maximization problem. Moreover, observing r_t is equivalent to observing the sequence

$$z_t \equiv \eta + \epsilon_t = r_t - a_t(\mathbf{r}_{t-1}). \quad (3.6)$$

By observing this sequence, the market learns about η, given normality and independence assumptions. The posterior distribution of η follows a normal distribution with means m_{t+1} and precision h_{t+1} given by, respectively,

$$m_{t+1} = \frac{h_t m_t + h_\epsilon z_t}{h_t + h_\epsilon} = \frac{h_1 m_1 + h_\epsilon \sum_{s=1}^{t} z_s}{h_1 + t h_\epsilon}, \quad (3.7)$$

$$h_{t+1} = h_t + h_\epsilon = h_1 + t h_\epsilon. \quad (3.8)$$

By applying Equation (3.7), we then can write Equation (3.3) as:

$$w_t(\mathbf{r}_{t-1}) = m_t(\mathbf{z}_{t-1}) + a_t(\mathbf{r}_{t-1}). \quad (3.9)$$

The expected premium associated with the past rating is:

$$Ew_t(\mathbf{r}_{t-1}) = \frac{h_1 m_1}{h_t} + \frac{h_\epsilon}{h_t} \sum_{s=1}^{t-1} (m_1 + a_s - Ea_s(r^{s-1})) + Ea_t(\mathbf{r}_{t-1}). \quad (3.10)$$

[7] We focus on workers' reaction to the fee introduction or increase; we do not address the optimal time k when the fee should be introduced to maximize the platform's profits.

[8] Even without analyzing platforms' business strategy, we might expect that, in a first period, it imposes no or very low fees to attract workers. This well-known firm strategy supports rapid growth and market share (Belleflamme and Peitz, 2015). In practice, platforms often change their pricing structure or increase their fees over time. For example, in 2015, AMT doubled its commission fees for requests of more than ten workers (see `https://www.businessinsider.com/amazon-mechanical-turk-price-changes?r=US&IR=T`). In 2022, five thousands sellers on Etsy.com went on 'strike' after the platform announced record revenues and a 30% fee increase (see `https://www.theverge.com/2022/3/30/23001727/etsy-seller-strike-boycott-fee-increase`).

From Equation (3.10), it follows that for a non-stochastic equilibrium path of labor supply, the marginal return of the expected premium to a_s for all $s \in \{1, ..., t-1\}$ in period t will be $\alpha_t = h_\epsilon / h_t$, irrespective of labor inputs in other periods. The maximization problem in Equation (3.5) is then:

$$\max_{a_{(\cdot)}} \sum_{t=1}^{\infty} \beta^{t-1}[f + \frac{h_1 m_1}{h_t} + \alpha_t \sum_{s=1}^{t-1}(m_1 + a_s - Ea_s(r^{s-1})) + Ea_t(\mathbf{r}_{t-1}) - Eg(a_t(\mathbf{r}_{t-1}))] - \\ - \sum_{t=k}^{\infty} \beta^{t-1}\phi[f + \frac{h_1 m_1}{h_t} + \alpha_t \sum_{s=1}^{t-1}(m_1 + a_s - Ea_s(r^{s-1})) + Ea_t(\mathbf{r}_{t-1})]. \tag{3.11}$$

Next, we maximize Equation (3.11) with respect to a_t and obtain, after rearranging:

$$\sum_{s=t}^{\infty} \beta^{s-t}\alpha_s - \sum_{s=t}^{\infty} \beta^{s-t} I_s \phi \alpha_s = g'(a_t(\mathbf{r}_{t-1})), \tag{3.12}$$

where I_s is an indicator function that takes the following value, depending on the time:

$$I_s = \begin{cases} 0, & s < k \\ 1, & s \geq k. \end{cases}$$

As t tends to infinity, α_s tends to 0. Therefore, the equilibrium sequence of labor inputs goes asymptotically toward 0. As long as the talent of the worker is unknown, there are returns to supplying labor. However, over time, the market learns the true value of η. At the limit, there are no returns to trying to use labor input to bias performance evaluations, so the labor input goes to 0. Comparing Equation (3.12) against the first-order condition in Holmström (1999),[9] we can observe that the marginal return to labor supply decreases with the fee requested by the platform.

3.3.1 Ratings as Switching Costs

Consider now a setting with two identical platforms. In line with the current regulatory situation in Europe, we start with a scenario in which no reputation portability is possible. Then for a second, hypothetical regulatory

[9] In Holmström (1999):

$$\gamma_t \equiv \sum_{s=t}^{\infty} \beta^{s-t}\alpha_s = g'(a_t^*(y^{t-1})).$$

regime, we imagine a policy setting that features reputation portability. Then we presume the right to data portability provided by Article 20 of the GDPR would also include reputation data.

Policy Regime without Reputation Portability

Two platforms (% and #)[10] are initially identical and set the same fee, which we normalize to 0. Both platforms offer a platform-specific reputation mechanism, so reputation built on one platform cannot be transferred to the other platform. Platforms remain identical until time k. Then at time k, Platform% raises the ad valorem fee to ϕ, while Platform# maintains its fee at 0. Therefore, these two platforms unequally capitalize on their workers, because only one of them introduces a fee. We abstract from strategic behaviors between platforms and assume that the fee increase on Platform% happens for an exogenous reason, such as a new tax that is passed on to users. For example, Google passed the cost of the UK's digital services tax on to British advertisers, raising its fees by 2%.[11]

Assume workers are not aware of the fee until time k,[12] at which moment, they have two choices: (1) remain on Platform%, to keep benefiting from the reputation investment made so far but have their income reduced by the increased fee, or (2) switch to Platform#, which does not impose a fee but requires workers to rebuild their reputations from scratch. To simplify the analysis and avoid asymmetric information (i.e., the workers know more about themselves than the market), we assume that following a platform switch, the learning process depicted in Equation (3.7) restarts. Even if workers know their own skills, available tasks, and how the new platform works, they reasonably will remain somewhat uncertain about how their skills will be evaluated by the new market.[13] Thus, after time k, workers face a new problem and will stay on Platform% if

$$\sum_{t=1}^{\infty} \beta^{t-1}[(1-\phi)c_{k+t-1} - g(a_{k+t-1})] \geq \sum_{t=1}^{\infty} \beta^{t-1}[c_t - g(a_t)]. \tag{3.13}$$

[10] Similar to Hossain and Morgan (2009), we avoid using numbers or symbols that might be associated with an order of preference.

[11] See https://www.theguardian.com/media/2020/sep/01/googles-advertisers-will-take-the-hit-from-uk-digital-service-tax.

[12] Otherwise, they would realize that subscribing to Platform# is always more profitable.

[13] Imagine a worker with a good reputation on Platform%, which informs this worker of their talent. Still, when switching platforms, this worker seems likely to exert substantial effort to gain an equally good reputation on the new platform or to impress the new employer.

The left-hand side of inequality (3.13) represents the utility of the worker, reduced by the fee, associated to the decision of staying on the platform. The right-hand side, instead, represents the utility of the worker associated with the decision of switching to the other platform. What is critical to notice here is that the difference between the utility obtained on Platform% versus the utility on Platform# is equivalent to the premium associated with past ratings, diminished by the fee.[14] By sticking with Platform%, at time k workers enter into a revenue scheme that accounts for past ratings obtained thus far:

$$c_k = f + w_k(r^{k-1}).$$

However, by switching platforms, all past ratings from Platform% are lost, and on Platform#, the worker has to restart from scratch. The inequality (3.13) implies that the fee increase does not trigger switching provided that the following inequality is satisfied:

$$\phi \leq \frac{\sum_{t=1}^{\infty} \beta^{t-1}[c_{k+t-1} - g(a_{k+t-1})] - \sum_{t=1}^{\infty} \beta^{t-1}[c_t - g(a_t)]}{\sum_{t=1}^{\infty} \beta^{t-1} c_{k+t-1}}. \tag{3.14}$$

Because it is not possible to find an analytical solution to Equation (3.14), in the Appendix (3.7.2), we identify the existence of a fee that matches the inequality for some range of parameters β, f, m_1, h_1, and h_ϵ.

Our model is similar to an ultimatum game (Güth et al., 1982), in which the proposer is the platform and the responder is the worker. If the worker has pure monetary motives, the maximum fee compatible with no switching represents the lowest offer workers are willing to accept. If the fee exceeds this value, workers refuse the offer and switch to the other platform. In the experiment, we expect workers with purely monetary motives to switch any time their expected utilities are higher on the other platform. Thus, we offer the following hypothesis:

[14] In the experiment, we also consider the switching behavior of workers if two platforms equally capitalize on them, such that both introduce the fee simultaneously. In that case, the inequality (3.13) becomes:

$$\sum_{t=1}^{\infty} \beta^{t-1}[(1-\phi)c_{k+t-1} - g(a_{k+t-1})] \geq \sum_{t=1}^{\infty} \beta^{t-1}[(1-\phi)c_t - g(a_t)].$$

Unlike an unequal capitalization of lock-in effects, we expect that workers are less likely to switch if platforms equally capitalize on their workers.

Hypothesis 1: *A policy regime without reputation portability enables the creation of switching costs, implying that workers are willing to pay a positive fee to stay on the platform they have built their reputation on.*

Other factors could explain switching behavior by workers. Considering the game structure and that of the experiment, workers' switching behavior may be motivated by monetary motives *and* fairness preferences. It is important to study and verify if workers feel they are treated unfairly because it not only influences the possible switching decision, but it can negatively affect workers' performance, which, in turn, can decrease the overall appeal of online labor markets. Workers with fairness preferences face an additional disutility when the platform introduces a fee because they also perceive it as unfair. Thus, the fee in Equation (3.14) would not be compatible with the no switching condition if the platform fails to account for the fairness preferences of the worker. We capture this disutility created by workers' fairness preferences by adding a negative parameter $\delta(\phi) \in [0, \infty)$, increasing in ϕ. Then a worker with fairness preferences will remain on Platform% if

$$\sum_{t=1}^{\infty} \beta^{t-1}[(1-\phi)c_{k+t-1} - g(a_{k+t-1})] - \delta(\phi) \geq \sum_{t=1}^{\infty} \beta^{t-1}[c_t - g(a_t)]. \quad (3.15)$$

Workers may have varying levels of tolerance for the fee, which could explain their switching behavior. Those workers for whom $\delta = 0$ are those with pure monetary motives, as depicted in Equation (3.13). Respondents with $\delta \to \infty$ always switch, because they have strong fairness preferences and cannot tolerate the imposition of even the smallest fee. Other workers might perceive the fee increase as unfair ($\delta > 0$) but tolerable, such that they would not switch if the compatibility constraint in Equation (3.15) is respected. These workers exhibit both monetary motives and fairness preferences. Workers with fairness preferences, who confront a platform fee but tolerate it, endure the highest losses when reputation is not transferable. Thus, a policy regime with reputation portability could be especially beneficial for workers with fairness preferences, because switching would not imply the loss of reputation investments.

We expect that some workers exhibit fairness preferences and switch platforms after a fee increase, even if they suffer a wage loss from doing so. If the utility streams between the two platforms are identical, then, as a tie-breaking rule, we expect workers with fairness preferences to switch.

Applying these considerations, we offer the following hypothesis:

Hypothesis 2: *Workers with fairness preferences are ceteris paribus willing to pay a lower fee to stay on the platform they have built their reputation on.*

Policy Regime with Reputation Portability

If reputation portability were mandated by regulation, which would constitute an extension of Article 20 of the GDPR, all workers could import their ratings when switching to a new platform. Platforms even might implicitly enforce reputation portability by buying data to screen the quality of new workers before allowing them to join the platform. Therefore, workers do not lose their reputation investments and can easily switch between platforms.[15] In this context, we suppose that two platforms competing for workers set the lowest fees possible. Assuming symmetry between the two platforms, Bertrand competition would follow, and the platforms would set a fee equal to marginal costs, which we assume for simplicity to be 0. Therefore, we presume that workers that have access to reputation portability naturally switch more often, because switching costs are 0.

Hypothesis 3: *In a policy regime with reputation portability, workers that have built a reputation do not accept any fee because there are no switching costs.*

3.4 Experimental Design

In this section, we describe the experimental design that allows us to analyze our hypotheses, and we present the sample.

3.4.1 Treatments

With a fictitious online labor market, we implement three interventions, combined into a lab-in-the-field experiment with seven to ten rounds. Workers were randomly assigned to either a treatment or control condition,

[15] We implicitly assume that both platforms consider ratings on the other platform trustworthy. In other words, there is perfect interoperability between the reputation systems of the two platforms.

within a 2 × 2 × 2 between- and within-subject experimental design. In accordance with our theoretical model, ratings yield a premium, such that a higher rating is associated with a higher wage in the next round. With a probability of 50% participants are randomly assigned to one of two policy regimes, one that allows for the portability of participants' ratings, and the other that does not. Then during each round, starting with round four, with a 25% probability, participants confront a platform fee that remains in force after it has been introduced. Finally, to identify switching due to monetary motives or fairness preferences, we compare platform switching behaviors when (1) the platforms are perfectly identical and simultaneously charge fees with the same amount (equal platforms) and (2) platforms are asymmetric, because only the platform the participant currently works on charges a fee while the other one does not (asymmetric platforms). Recall that participants are randomly assigned to these two platform conditions with 50% probability.

In our experiment, there was no human interaction between platform provider and worker, because a pre-programmed mechanism decided to introduce and increase a fee. Therefore, it could be argued that workers may not have been prompted to switch platforms or show fairness preferences. Blount (1995) notes that the perceived intentions and identity of the proposer influence the responder's reaction, such that reciprocity tends to be weaker when the proposer is a machine engaged in random assignments and stronger if the proposer is human. We nevertheless assume that the participants' reactions should mimic the real-life responses of online workers, because we recreate the working conditions and environment for workers on online platforms (Henrich et al., 2001). Finally, if the proposer's machine identity influences the responder's reaction, the effect sizes we identify would form lower bounds and represent conservative estimates.

We identify switching based on fairness preferences if and only if, in response to a fee increase, workers switch to another platform where they earn an equal or lower wage (scenario 1). However, if workers respond to a fee increase by switching to another platform that pays them a higher wage, switching might occur because of both fairness preferences and monetary motives (scenario 2). Switching as a signal of fairness preferences can occur in every treatment condition and is subject to participants' ratings, whereas monetary motives by definition cannot be elicited when participants' ratings are portable and the platforms are equal.

By subtracting the fraction of workers who switch with pure fairness

preferences (scenario 1) from the fraction of workers who switch in line with fairness preferences and/or monetary motives (scenario 2), we obtain the fraction of workers who solely switch for monetary reasons. Table 3.1 provides an overview of our experimental treatments and the number of observations we collected in each treatment.

— Table 3.1 about here —

With this experimental design, we also can examine second-order effects pertaining to the strength and frequency of platform capitalization due to lock-in effects. In the experiment, the platform fees take varying levels (\$0.00, \$0.01, \$0.05), which allows to compare switching behavior with an initial fee of \$0.01 (i.e., low capitalization of lock-in) versus an initial fee of \$0.05 (i.e., high capitalization of lock-in).[16] If a platform introduces a fee of \$0.01, there is a 25% probability in each subsequent round that the fee will increase to \$0.05, which will remain in effect until the end of the experiment. To test for second-order effects of the frequency of lock-in capitalization, we compare switching in response to an immediate high fee introduction versus a high fee increase that occurs after a low fee introduction.

3.4.2 Procedural Details

Our study was approved by the Ethics Commission, University of Bremen (project 2020-16), and is registered at the AEA RCT Registry (Ciotti et al., 2021). After being assigned randomly to the treatments, the study participants considered working in a new online labor market that contains two labor platforms: Platform% and Platform#. The experiment consisted of a minimum of seven and a maximum of ten rounds, each with the same structure. Starting with round seven, to prevent end round effects, a random mechanism decided with a $33.\bar{3}\%$ probability whether the study ended with the last round that had been completed. In each round, participants began by choosing the platform on which they wanted to work. After making this decision, they had to complete a task on that platform, which consisted of counting zeros from a series of zeros and ones. After completing each task, participants received a performance rating, displayed as an average that reflects their past performance across all transactions in previous rounds. In each round, the minimum amount offered

[16] Note that *initial* in this context indicates that the fee might be raised in later rounds; it does not refer to the first round of an experiment.

to complete a task was \$0.10. The rating, which is based on participants' performance, also affected their wage level in the next round. Depending on their rating (ranging from 1 to 5 on each platform), participants could earn more money for a task, such that they received \$0.15 if their rating exceeded 3.50 and \$0.20 for a rating greater than 4.50.

Participants received information about their ratings, the platform's introduction or increase of a fee starting in the next round, wages for the next task, and the total wages over all rounds after each task, separately for Platform% and Platform#. With this information, participants again had to choose which platform to work on in the next round and perform another zero-counting task. During the first three rounds, we avoided charging fees so that participants could establish a rating first, which created the possibility of lock-in.

3.4.3 Sample

The study participants were recruited from AMT, an online marketplace for crowdsourcing microtasks, i.e. small and repetitive tasks including answering surveys, testing websites or categorizing images (Amazon Mechanical Turk, 2022c). On AMT, contractors post tasks, called Human Intelligence Tasks (HITs), in the form of an open call to geographically dispersed workers. Workers can choose between the available HITs for which they will be paid. Contractors can then either accept or reject the completed task. To signal the quality of workers, AMT uses different qualification types: the HIT approval rate—the rate of approved tasks that workers have completed in the past—and the master qualification, which is awarded to workers who have demonstrated excellence by completing a wide range of HITs on AMT (Amazon Mechanical Turk, 2022b). The resulting qualification types can serve as exclusion criteria for contractors, because they indicate certain qualifications of workers before HITs are posted. For each HIT, contractors have to pay a 20% fee on the amount they pay workers, plus an additional 20% fee if more than ten HITs are published (Amazon Mechanical Turk, 2022a). While the fees are paid by contractors, we assume a full pass through of the fee from the contractors to the workers. In a similar vein, Semuels (2018) has noted that AMT has doubled its fees since 2015, which resulted in workers complaining about contractors offering less money.

As one of the largest online labor platforms in the world (Pittman and

Sheehan, 2016), AMT provides participants who are real online workers, and it represents a much larger respondent pool than other services can offer (Sheehan, 2018), which also implies greater diversity in their backgrounds (Mason and Suri, 2012). Various studies have successfully replicated established economic and psychological effects in empirical validations of AMT as a useful data collection tool (Paolacci et al., 2010; Sprouse, 2011; Crump et al., 2013; Litman et al., 2015; Buhrmester et al., 2016; Hillebrand et al., 2023).

The participants were all at least 18 years of age and citizens or legal residents of the United States.[17] We collected the data between February 12 and 23, 2021, using the software Unipark. We recruited a total of 2,148 participants but excluded those who provided invalid information[18] about working hours or weekly income from online labor and who monotonously switched back and forth between platforms during the experiment. We also removed participants who received the lowest possible rating of 1 in every round or who consistently failed to identify the correct number of zeros (i.e., were accurate no more than twice). This allowed us to exclude bots and participants who click randomly during the task without paying attention. The final sample includes responses from 1,622 participants. On average, each experimental session lasted about 20 minutes, and participants earned an average of $1.36 plus an additional fixed amount of $1 for participating.[19]

3.5 Experimental Results

In Section 3.5, we first present evidence whether platform fees trigger switching behavior of online workers. Then we analyze the role of reputation portability on switching behavior. Next, we examine workers' motives to switch platforms and concentrate our analysis on monetary motives and

[17] A filter applied during the tendering process on AMT and an additional query at the beginning of the experiment confirmed these criteria.

[18] Some participants reported working a total of more than 110 hours per week or responded that they work more than 150 hours per week on crowdsourcing platforms. In addition, there were also workers who reported earning more than $3,000 and up to $78,000 per week from crowdsourcing.

[19] Because the experiment could be completed in approximately 20 minutes, these payments correspond to an hourly remuneration ranging from $6.75 up to $8.70, above the average payment on AMT (Hara et al., 2018) and in line with the federal minimum hourly wage in the United States of $7.25 (29 USC Chapter 8, Section 206 – Minimum Wage Statutes).

fairness preferences. We then focus on the effect of reputation portability on working conditions in online labor markets. Finally, we investigate how the strength and frequency of the platform's capitalization of workers' lock-in influence switching behavior. When comparing the means across treatments, we apply two-sample chi-square tests of proportions, Fisher's exact tests, and two-sample t-tests.[20]

The Impact of a Fee Introduction on Switching Behavior

With a within-subject analysis, we first determine if introducing a fee prompts participants to switch platforms. In the experiment, 1,349 participants (83.2%) confronted a fee, whereas 273 participants (16.8%) never encountered these charges.[21] Figure 3.1 illustrates the differences in switching behavior when a platform introduces a fee, versus switching in all rounds before any fee was charged. In line with our prediction that switching behavior triggered by a platform fee differs from switching behavior in prior rounds without a fee, we find that the fraction of participants switching platforms increases from 24.4% to 38.6% following a fee, a significant increase of 14.2 percentage points (two-sample chi-square test of proportions, $z = 6.025, p < 0.001$). Figure 3.2 also reveals that this effect is driven mostly by switching behaviors if platforms are asymmetric. Switching platforms prior to a fee might be explained by curiosity, a strategic desire to build good ratings on multiple platforms to avoid the costs related to a lack of reputation portability,[22] or an effort to avoid the negative implications of a poor rating received in earlier rounds, which also requires a policy regime without

[20] Table 3.2 provides a randomization check using F-tests to determine whether the computerized randomization created a balanced sample. These results indicate that the F-tests for risk ambiguity, the tasks completed and the approval rate obtained on AMT are statistically different from zero. We therefore include these variables as control variables in our regression analyses presented in Tables 3.3 to 3.5.

[21] In the round the fee was introduced, 10.8% had a rating of less than 3.50, 14.9% had a rating between 3.50 and 4.49, and 74% had a rating greater than 4.50.

[22] Prompted by an item in the questionnaire, a participant offered a reason for switching platforms: "I felt it was wise to create a high rating on each platform. That way if there was a difference in the fee or I made a mistake, I could use the platform with the highest rating since it would be saved from when I switched from it."

reputation portability.[23] We summarize this finding as follows:

Result 1. *Introducing a platform fee increases switching behavior, if platforms are asymmetric.*

— Figures 3.1 to 3.2 about here —

The Effect of Reputation Portability on Switching Behavior

Can a policy regime that mandates reputation portability mitigate the lock-in effects in online labor markets? To answer this question, we compare switching behavior after a platform introduces a fee in regimes with and without reputation portability. As noted previously, if switching increases more in the a policy scenario with portability, it offers evidence that workers are vulnerable to lock-in effects that arise in the absence of reputation portability. As detailed in Figure 3.3, switching behavior in a policy regime without reputation portability increases after a fee, from 18.3% to 23.3%. However, the 5 percentage point increase is not significant (two-sample chi-square test of proportions, $z = 1.380, p = 0.168$), which is in line with Hypothesis 1, stating that platforms can capitalize lock-in effects in a policy regime without reputation portability. In a policy regime with reputation portability though, switching behavior increases by 23.8 percentage points, from 30.7% to 54.5%, which is statistically significant (two-sample chi-square test of proportions, $z = 7.643, p < 0.001$). The difference between these increases (5 versus 23.8 percentage points) also is statistically significant (Fisher's exact, $p < 0.001$), supporting Hypothesis 3 that the policy regime with reputation portability increases the probability of switching platforms. Therefore,

Result 2. *Platforms can capitalize lock-in effects more effectively in a policy regime without reputation portability, whereas a policy regime with reputation portability significantly increases switching behavior and reduces the chances that workers in online labor markets will be at risk from the imposition of a platform fee.*

[23] We check whether the rating differs systematically across participants who switched and those who did not in rounds before the fee increase and find that they are significantly different (two-sample t-test, $t = 5.975, df = 5,049, p < 0.001$). That is, some workers left the focal platform due to a poor rating. Those who switched had a rating of 3.60, compared with an average of 4.62 for those who did not switch.

— Figure 3.3 about here —

The Motives to Switch Platforms

We now analyze more thoroughly *why* participants switch platforms in response to a fee, and how reputation portability affects these switching motives. In our experimental design, workers may be motivated by monetary reasons and/or have fairness preferences, such that they might react to platform fees even in the absence of monetary incentives to switch (Dhami, 2016). If workers with fairness preferences perceive the fee as unfair, they might switch to another platform, even if they earn the same or a lower wage. But if workers earn a higher wage on the other platform, they could be motivated by both their fairness preferences and their monetary motives. Additionally, their behaviors also should depend on their tolerance level for fees.

Of the 1,349 participants who encountered a fee, 417 would have earned a higher wage on the other platform, so their platform switching might reflect monetary motives, fairness preferences, or both. As displayed in Figure 3.4, we find that 327 (78.4%) workers switched platforms in this setting. For 932 participants, the fee increase coincided with an equal or lower wage available on the other platform; specifically, 447 workers would have earned the same wage in the next round, and 485 would have earned less, had they switched platforms. Overall, 194 (20.8%) workers switched platforms (148 who earned an equal wage and 46 participants who earned less), exhibiting their fairness preferences.

To calculate the fraction of workers who switched solely for monetary reasons, we subtract the 20.8% fraction of workers who switched due to pure fairness preferences (t-test against zero, $t = -59.512, df = 931, p < 0.001$) from the 78.4% fraction of workers whose switching behavior signaled fairness preferences and/or monetary motives (t-test against zero, $t = -10.700, df = 416$, $p < 0.001$). The difference of 57.6 percentage points identifies workers who switched solely for monetary reasons. The difference in switching motives is statistically significant (two-sample chi-square test of proportions, $z = 12.837, p < 0.001$). Overall, our findings are in line with Hypothesis 2, in which we predicted that workers with fairness preferences are ceteris paribus willing to pay a lower fee to stay on the platform they have build their reputation on. When we consider switching behavior after a fee introduction for each portability regime separately (see Figure 3.5), we find a significant increase in pure switching

behavior due to fairness preferences, from 15.4% to 30.2%, when reputation portability exists (two-sample chi-square test of proportions, $z = 2.437, p = 0.015$). Interestingly, this result may suggest that workers with fairness preferences are more willing to punish the platform by switching if they are allowed to take their data with them. Since workers do not lose their ratings when they switch, punishment costs are lower. If participants earn more on the other platform after the fee is introduced, switching behavior in a policy regime with reputation portability increases from 72.6% to 80.1%. However, this difference is not statistically significant (two-sample chi-square test of proportions, $z = 1.346, p = 0.178$). Formally:

Result 3. *If a platform introduces a fee, 57.6% of workers switch based on monetary motives, and 20.8% switch due to fairness preferences. Moreover, the costs of "punishing" the platform by switching are lower for workers in a policy regime with reputation portability, as switching based on pure fairness preferences increases from 15.4% to 30.2%.*

— Figures 3.4 to 3.5 about here —

By investigating differences in their ratings in each round before and after a fee introduction, we test if workers perform differently after a newly imposed fee than before the fee. In Table 3.3, we present the results of ordinary least squares regressions and assess the *Rating in Round t* on the platform on which the participant currently works as the dependent variable. Our variable of interest is *Period after Fee*, which is equal to 1 in the rounds after the fee was introduced and 0 in prior rounds. In column 1, we investigate differences in performance for all workers who encountered a fee. Their rating in each round decreases significantly by 0.13 after the fee introduction, holding all other variables constant. In addition, we find that workers exhibit poorer performance than they did before the fee introduction if they (i) expressed fairness preferences (column 3), (ii) confronted a fee and a higher wage on the other platform but did not switch (column 4), and (iii) confronted a fee and the same or lower wage on the other platform and also did not switch (column 5). For workers who switched to a platform with a higher wage after the introduction of a fee (column 2), the difference in lowered performance is only weakly significant at the 10% level. These results are in line with our theoretical model, in which workers who confront a lower wage reduce their equilibrium effort accordingly, and with Fehr et al. (1993)

and Fehr and Falk (1999), who find that workers might reciprocate by lowering their effort in response to low wages.We conclude:

Result 4. *Except for workers who switch due to monetary motives when a platform introduces a fee, workers performance generally decreases after experiencing a fee.*

— Table 3.3 about here —

To validate our findings related to switching behavior based on monetary motives and fairness preferences, we also run a regression analysis, informed by responses to the questionnaire, such that we analyze in depth why participants chose to switch after being charged a fee. According to prior experimental research, risk-averse participants tend to prefer outcomes with low uncertainty over those with high uncertainty (Kahneman et al., 1991; Tversky and Kahneman, 1991), and ambiguity-averse participants prefer known over unknown risks (Ellsberg, 1961; Camerer and Weber, 1992). In addition to testing for the effects of risk attitudes, that is risk aversion and ambiguity aversion, and perceptions on switching behavior, we investigate whether switching behavior might constitute a form of negative reciprocity, such that workers seek to respond to the fee by punishing the platform, even at a cost to themselves (Güth, 1995; Kritikos and Bolle, 2001), or if they simply regard the fee as unfair, which is sufficient to prompt them to switch platforms (Kahneman et al., 1986; Rabin, 1993).

First, to classify workers according to their relative risk aversion we asked participants to choose their preferred lifetime earnings profiles (Butler et al., 2014). Second, we implemented a thought experiment developed by Ellsberg (1961) that requires participants to choose between two urns. Third, with measures of negative reciprocity from the 2005 personality questionnaire of the German socio-economic panel (DIW, 2023), we asked participants how much they agreed with six self-descriptive statements on 7-point Likert scales ranging from "does not apply to me at all" to "applies to me perfectly." Fourth, we solicited the main reasons participants switched by offering a list of seven options, then asking them to rank the reasons that applied, in order of importance.[24] The dummy variables *Boredom*, *Curiosity*, *Poor Rating*, *Earn*

[24]These choices were "I was bored," "I was curious," "I had a low rating," "I perceived the fee increase as unfair," "I could earn more money on the other platform," "I did not switch platforms," and "other reason."

Higher Wages, *Fee Perceived as Unfair*, and *Other Reason* were derived from their responses. All these dummy variables equal 1 if participants rank that reason for switching among the top three, suggesting that it represented a relevant consideration for them. The baseline category is *No Switching*. In addition, we control for the extent of lock-in by including participants' *Average Rating in Round k* and the *Round k*, i.e., the round the fee is introduced.

The probit regression involves only those participants who confronted a fee at some point during the experiment. The dependent variable is the dummy variable *Switching*, which indicates whether the worker switched platforms during the round of the fee introduction. The results in Table 3.4 corroborate our main findings. In column 1 participants' average rating has a negative effect on their switching behavior after the fee introduction. If the average rating (*Average Rating in Round k*) increases by one unit, the probability of switching decreases by 7.7% in response to a platform fee, all else being equal. This result confirms that reputation can lock-in workers. We also find strong support for our predictions about monetary motives and fairness preferences; both a desire to *Earn Higher Wages* and the perception that the fee is unfair (*Fee Perceived as Unfair*) significantly increase the likelihood that participants switch platforms. In detail, an opportunity to earn higher wages increases switching behavior by 27.8%, holding all other variables constant. Perceiving the fee as unfair increases this behavior by 18.2%, all else being equal. Our findings regarding fairness preferences remain consistent in column 2, where we specifically focus on participants who expressed pure fairness preferences. Risk aversion, risk ambiguity, negative reciprocity, a poor rating, and the round in which the fee was introduced do not influence workers' switching behaviors, though boredom and curiosity increase them. We summarize the regression findings as follows:

Result 5. *The better the rating, the less likely workers are to switch. The desire to earn higher wages and perceiving a fee as unfair significantly increase workers' switching behaviors; risk aversion, risk ambiguity, negative reciprocity, and a poor rating do not.*

— Table 3.4 about here —

Did a significantly higher proportion of participants who switched and exhibited fairness preferences report perceiving the fee in the questionnaire as unfair compared to other participants who were also confronted with the fee?

We conduct a Fisher's exact test and find that 39.7% of workers with fairness preferences, but only 27.5% of all other workers, reported that they perceived the fee as unfair in the questionnaire. This difference is statistically significant ($p = 0.001$), which implies that workers who expressed fairness preferences perceived the fee indeed as more unfair.

The Effect of Reputation Portability on Working Conditions

Next, we investigate the effect of a policy regime with reputation portability on working conditions in online labor markets. We begin with an analysis of switching behavior in both policy regimes, accounting for worker reputation. In our experimental setup, a rating greater than 3.50 is associated with higher wages. We thus anticipate that the lock-in effects might be particularly strong for highly rated workers. Figure 3.6 sheds light on the differential switching behaviors. Workers with ratings below 3.50 switch significantly more often in rounds prior to the fee if reputation is not portable across platforms compared to when that is the case (two-sample chi-square test of proportions, 66.4% vs. 39.1%, $z = -4.596, p < 0.001$). After a fee is introduced, the difference in switching behavior for workers with poor ratings is only weakly significant at the 10% level and differs by 17.4 percentage points between the two policy regimes, 75.6% versus 58.2% (two-sample chi-square test of proportions, $z = -1.769, p = 0.077$). One could argue that a policy regime that allows for reputation portability could potentially increase the quality of the signal of workers' talents. In such a scenario, poorly rated workers are less likely to switch frequently, because they are unable to erase their rating history. However, high-quality workers switch more often after the introduction of a fee because expressing their preferences is associated with less costs than in a policy regime without reputation portability. When confronted with a fee, we find that workers with ratings higher than 3.50 switch significantly more often in a policy regime with reputation portability than do workers with comparable ratings but without reputation portability (two-sample chi-square test of proportions, for ratings between 3.50 and 4.49, 20.5% vs. 46.9%, $z = 1.978, p = 0.048$; for ratings greater than 4.50, 14.6% vs. 55.8%, $z = 6.304, p < 0.001$). In summary, a policy regime with reputation portability leads to more platform switching after a fee is introduced among high-quality workers.

We continue by analyzing the effect of a policy regime with reputation portability on workers' wages, if these workers experienced platform

capitalization. In Table 3.5, we run several ordinary least squares regressions with the *Total Wage* the participant earned by the end of the experiment as dependent variable. Our variable of interest is *Portability*, which is a dummy variable equal to 1 if the worker was assigned to the a policy regime with portability and 0 otherwise. Considering all ratings by the end of the experiment in column 1, the effect of portability on earnings is only weakly significant at the 10% level. In column 2, we run the same regression for workers with a rating of less than 3.50 at the end of the experiment. We find that a policy regime with portability decreased these workers' total wages by \$0.13, holding all other variables constant. For workers that encountered a rating between 3.50 and 4.49 in the last round, we do not find an effect of reputation portability on wages (column 3). Lastly, we evidence that a rating greater than 4.50 at the end of the experiment significantly increased workers' total wages by \$0.07, all else equal. Our findings suggest that a regulatory regime with reputation portability can function as a mechanism to empower in particular highly rated workers in online labor markets. We summarize these findings as follows:

Result 6. *Lock-in effects affect high-quality workers more than poorly rated workers. In addition, a policy regime with reputation portability increases high-quality workers' wages and significantly decreases wages of workers with a poor rating.*

— Figures 3.6 and Table 3.5 about here —

The Strength and Frequency of Capitalizing Lock-In Effects

Recall that during the experiment, starting with round 4, a random mechanism decided, with a 25% probability, whether the platform introduced a fee of \$0.01 (low capitalization of lock-in) or \$0.05 (high capitalization of lock-in). Once participants were subject to this platform fee, it remained in effect, but we also allowed platforms that introduced a fee of \$0.01 to raise it to the \$0.05 in each following round, again with a probability of 25%. With this mechanism, we can determine if high initial capitalization of lock-in effects triggers significantly more switching than a lower initial level of capitalization. Furthermore, we test whether the frequency of fee increases affects switching behaviors, according to the fraction of switchers from a platform that immediately introduces a \$0.05 fee versus one that charges a fee of \$0.05 only after it introduced a fee of \$0.01 in previous rounds.

We start our investigation with the role of fee size on switching behavior. As depicted in Figure 3.7, 35% of participants switch platforms on average if the platforms introduce a fee of \$0.01, whereas 42.1% switch if the platform directly introduces a fee of \$0.05. This increase in switching behavior differs by 7.1 percentage points, which is only weakly significant at the 10% level (two-sample chi-square test of proportions, $z = 1.649, p = 0.099$). As detailed in Figure 3.8, the result is driven by switching behavior if platforms are asymmetric (two-sample chi-square test of proportions, 48.5% vs. 61.9%, $z = 2.581, p < 0.001$). With regards to the portability regimes, we do not find a significant effect between switching behavior and the levels of capitalization of lock-in (Figure 3.9. However, regardless of the size of the fee introduction, we evidence that switching is significantly larger in a policy regime with reputation portability, which again highlights that workers are less vulnerable to platform capitalization (two-sample chi-square test of proportions, fee of \$0.01, 19.6% vs. 50.6%, $z = 4.299, p < 0.001$; fee of \$0.05, 26.8% vs. 58.2%, $z = 5.019, p < 0.001$). Formally:

Result 7. *If platforms are asymmetric, workers are more likely to switch when the platform they work on immediately introduces a high fee rather than a low fee.*

— Figures 3.7 and 3.9 about here —

To determine if the frequency of lock-in capitalization by platforms affects switching behavior, we test for a difference in platform switching between participants immediately confronted with a \$0.05 fee versus those who first experienced a fee of \$0.01 and then a fee of \$0.05 in a later round.[25] As Figure 3.10 shows, workers switch significantly more often if a platform initially introduces a fee of \$0.05, compared with the step-up situation in which the platform initially introduced the \$0.01 fee and then increased it to \$0.05 (two-sample chi-square test of proportions, $z = 3.004, p = 0.003$). This result is explained by switching behavior if platforms are asymmetric (see

[25]If both platforms are perfectly identical, it does not matter if workers are currently active on Platform% or Platform#, because they have to pay the fee on both platforms regardless of their switching behavior. Recall that if platforms are asymmetric, only the platform the worker currently works on introduces (and potentially later increases) a fee, while the other platform never charges a fee. Therefore, in the case of asymmetric platforms, we consider participants who did not switch platforms after the \$0.01 fee introduction and thus faced a fee increase to \$0.05.

Figure 3.11, two-sample chi-square test of proportions, 16.7% vs. 61.9%, $z = 3.332, p < 0.001$) and by switching platforms in a policy regime with reputation portability (see Figure 3.12, two-sample chi-square test of proportions, 28.4% vs. 58.2%, $z = 3.090, p < 0.001$). In a policy regime without reputation portability, or if the platforms are perfectly identical, we do not find a significant effect. This finding is in line with our model prediction: as platforms equally capitalize on their workers, or as workers are unable to transfer their ratings, the utility associated with the decision of switching is relatively low and can hardly trigger switching (see Equation 3.13). In summary,

Result 8. *If only the platform on which workers currently work charges a fee, workers are less likely to switch platforms if they experience rising subsequent fees. If the platforms are identical, switching behavior does not depend on the frequency of fees. In a policy regime with reputation portability, workers are also less likely to switch in a situation with rising subsequent fees, whereas in a policy regime without reputation portability, the frequency of fees does not affect switching behavior.*

— Figures 3.10 to 3.12 about here —

3.6 Conclusion

This study represents a first effort to investigate the capitalization of lock-in effects by online platforms and the influence of reputation portability on lock-in effects and lock-in capitalization of workers. Theoretically, we show that a platform can impose a fee on workers and sustain it over an infinite horizon without losing workers, if reputation portability is not made mandatory. Because its workers are locked in, the platform can capitalize their reluctance to switch. Experimentally, we conduct an online lab-in-the-field decision experiment and evidence that platforms can capitalize lock-in effects more intensely when reputation portability mechanisms are absent. Moreover, by disentangling switching behavior based on monetary motives and fairness preferences, we find that a policy regime with reputation portability substantially increases workers' switching behaviors, mainly due to monetary incentives, though fairness preferences also play a role. Our data further show that a fee charge has a negative impact on worker performance.

Our paper has direct implications for regulatory authorities and platform managers. First, the results show that reputation portability is valuable for workers to avoid platform capitalization, a goal that is particularly important in online labor markets where workers rely on valuable ratings of their quality and often face precarious working conditions, significant setup costs, and limits to multi-homing. The current analysis also informs questions about whether reputation data should be regulated. In line with the purposes of recent regulations such as the GDPR, the Californian Consumer Privacy Act, or the Chinese Personal Information Protection Law to make data easily transferable, we recommend the imposition of reputation portability rules to mitigate lock-in effects and improve the working conditions of high-quality online workers. In the European context, the introduction of reputation portability would mean to extend Article 20 GDPR, the Right to Data Portability, because reputation data do not fall within the scope of Article 20. In addition, introducing reputation portability in online labor markets could increase competition among platforms, which improves the bargaining power of workers. Second, our work also has managerial implications with regards to platform pricing. By distinguishing different switching motives, we show that workers respond with a lower performance after a platform introduces a fee, even after workers switched platforms. Therefore, the capitalization of worker lock-in through a platform specific rating could have a non-positive effect for platforms after all.

As relevant extensions to our work, we offer several potential options. First, we consider specifically the portability of reputation data mandated by regulation, but other designs, such as the right but not the obligation to transfer ratings to other platforms, also might influence lock-in capitalization and thus switching behavior (Hesse and Teubner, 2019). Second, researchers might address how platform competition changes when regimes implement reputation portability. In the presence of reputation portability, platforms may have greater incentives to coordinate on prices but are less motivated to invest in the overall quality of their marketplaces and reputation systems. In traditional network settings, such as telecommunications, the outcomes of number portability on providers' investments in quality remain uncertain (Bühler et al., 2006). Lower profit because of lower lock-in effects should a priori not jeopardize online platforms' investments when reputation becomes portable, as the virtual infrastructure may have similar or even lower maintenance and development costs. Third, an online market with imperfect

competition or frictions also might affect switching behavior differently. Allowing for reputation portability could reinforce the well-established positions of incumbent users and raise barriers to entry for new users of online marketplaces. Here again, these impacts might affect overall welfare in the market. Fourth and finally, further research might account for information asymmetries across platforms and users, as well as strategic choices by users to transfer their reputation when they have the right, but not the obligation, to reputation portability. For example, in a policy regime with voluntary reputation portability, the market might interpret a transfer of reputation data as a positive signal. We leave this question for further research.

3.7 Appendix

3.7.1 Figures and Tables

Figure 3.1. Fee Introduction

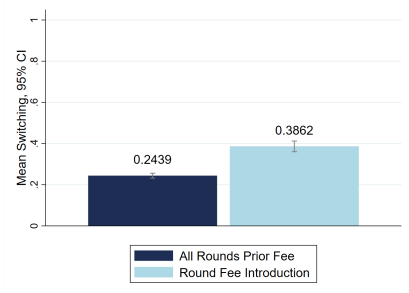


Figure 3.2. Fee Introduction and Platform Symmetry

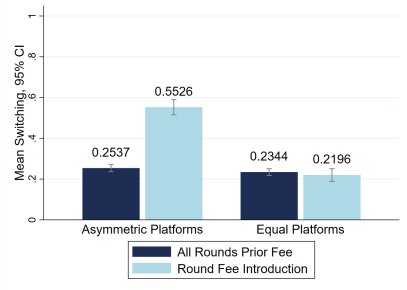


Figure 3.3. Portability Regime

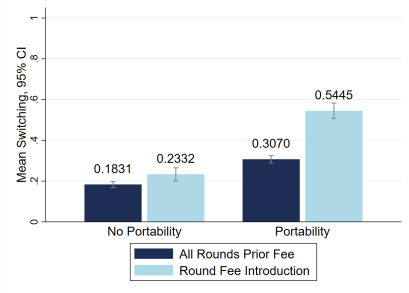


Figure 3.4. Monetary Motives and Fairness Preferences

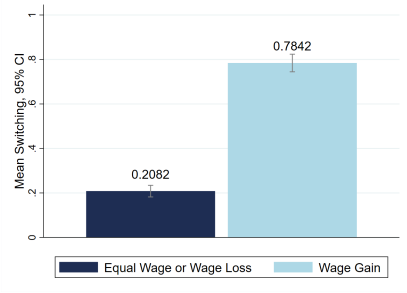


Figure 3.5. Monetary Motives, Fairness Preferences, and Portability Regime

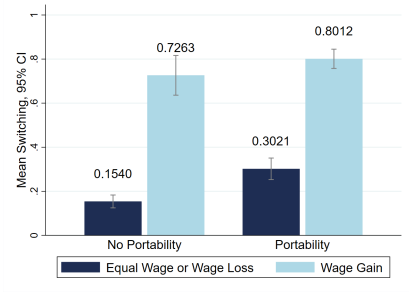


Figure 3.6. Ratings and Portability Regime

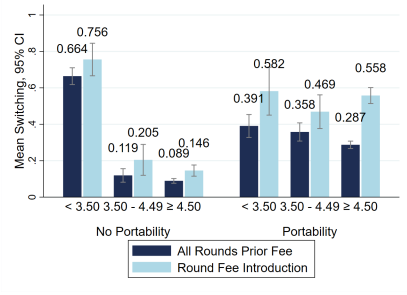


Figure 3.7. The Strength of Capitalizing Lock-In Effects



Figure 3.8. The Strength of Capitalizing Lock-In Effects and Platform Symmetry

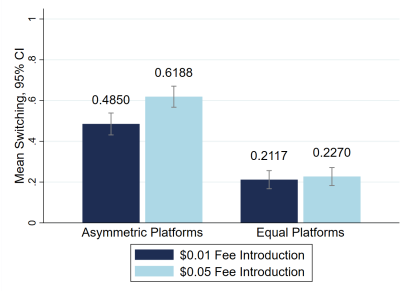


Figure 3.9. The Strength of Capitalizing Lock-In Effects and Portability Regime

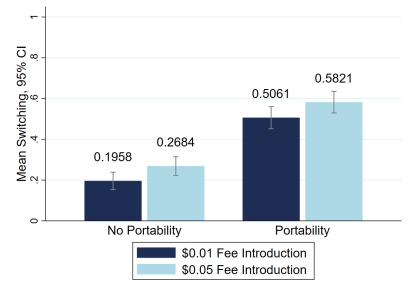


Figure 3.10. The Frequency of Capitalizing Lock-In Effects

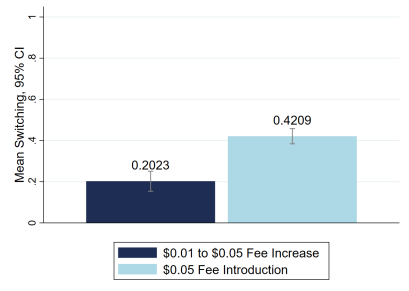


Figure 3.11. The Frequency of Capitalizing Lock-In Effects and Platform Symmetry

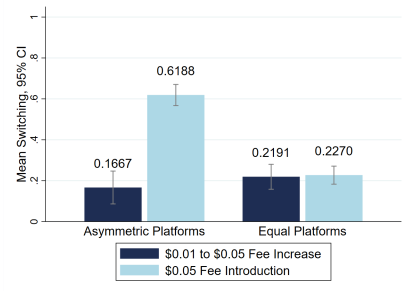


Figure 3.12. The Frequency of Capitalizing Lock-In Effects and Portability Regime

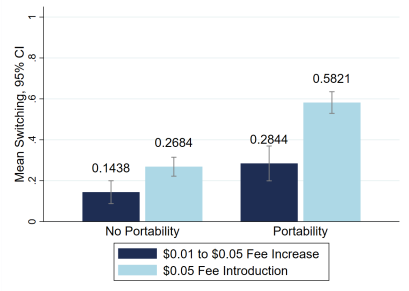


Table 3.1. Experimental Conditions

Conditions	Portability Regime	Platforms	Fee	N
1	No Portability	Equal	No	64
2	No Portability	Equal	Yes	334
3	No Portability	Asymmetric	No	72
4	No Portability	Asymmetric	Yes	352
5	Portability	Equal	No	65
6	Portability	Equal	Yes	340
7	Portability	Asymmetric	No	72
8	Portability	Asymmetric	Yes	323
				1,622

Notes: The table shows the experimental treatment conditions. Participants in treatment conditions 1, 3, 5, and 7 were not affected by a fee introduction or a fee increase, reflecting the randomized mechanism that decided before each round, starting in round 4, whether the platform would introduce a fee, with a probability of 25%.

Table 3.2. Randomization Check

	Conditions									
	1	2	3	4	5	6	7	8	R^2	F-test
Socio-Economic Background										
Age (yrs)	37.469	0.771	2.559	0.673	-2.423	-0.466	0.253	-0.661	0.006	0.221
Female and Diverse (y/n)	0.547	-0.136	-0.075	-0.098	-0.131	-0.106	-0.099	-0.157	0.005	0.363
Education (yrs)	15.75	-0.178	-0.083	-0.071	-0.119	-0.062	0.347	-0.199	0.004	0.458
Weekly Working Hours	34.845	1.830	1.517	2.776	3.433	2.086	-0.760	1.627	0.002	0.752
Annual Inc. ($)	34,297	3,622	3,411	4,680	972	5,696	3,342	2,932	0.002	0.799
Work Experience										
Hours Online Labor	19.266	-0.355	-1.224	-1.428	0.365	-0.133	-2.738	-0.086	0.003	0.755
Weekly Inc. Online Labor ($)	76.875	2.667	-7.833	4.483	21.679	3.269	26.569	1.633	0.004	0.786
Platform Registrations	1.953	0.724	-0.120	-0.050	0.847	0.088	0.186	-0.139	0.006	0.489
Completed Tasks AMT	10,428	14,388	30,288	16,677	19,913	17,387	-1,415	15,009	0.003	0.000
Approval Rate AMT (%)	97	0.042	1	-0.152	0.692	-0.956	-3.139	-0.947	0.005	0.061
Preferences										
Risk Aversion (0-1)	0.125	0.016	0.014	0.057	-0.033	0.054	0.000	0.005	0.005	0.245
Risk Ambiguity (0-1)	0.672	-0.172	-0.130	-0.180	-0.118	-0.187	-0.067	-0.146	0.008	0.056

Notes: This table provides the results from ordinary least squares regressions with treatment dummies as independent variables. The questionnaire, completed by participants after the experiment, is the source of the dependent variables. The treatment conditions are in Table 3.1. The omitted treatment condition is condition 1, a policy regime without reputation portability, equal platforms, and no fee. The first column shows the mean values of this treatment condition. The last column shows the p-values of the F-test of joint significance of the treatment dummies. Gender is coded 1 if participants reported being female and/or gender-diverse ($n = 6$) and 0 if male. Robust standard errors (not shown). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.3. Performance in Rounds Prior a Fee vs. After Fee Introduction

	Rating in Round t				
	(1) Full Sample	(2) Wage Gain	(3) Equal Wage or Wage Loss	(4) Wage Gain Situation	(5) Equal Wage or Wage Loss Situation
Period after Fee	-0.129***	-0.073+	-0.191***	-0.241**	-0.123***
	(0.022)	(0.043)	(0.073)	(0.108)	(0.027)
Controls					
Risk Ambiguity	0.214***	0.155+	0.382***	0.157	0.161***
	(0.037)	(0.086)	(0.101)	(0.216)	(0.043)
Completed Tasks AMT	0.002	0.023	-0.041	0.037***	-0.008
	(0.016)	(0.042)	(0.047)	(0.009)	(0.027)
Approval Rate AMT	0.401+	0.397	0.635	-0.725***	0.509+
	(0.205)	(0.308)	(0.412)	(0.267)	(0.304)
Intercept	4.061***	4.043***	3.708***	4.902***	4.054***
	(0.201)	(0.298)	(0.403)	(0.234)	(0.299)
Observations	12,365	2,999	1,769	831	6,766
Number of Workers	1,349	327	194	90	738
Adjusted R^2	0.017	0.007	0.040	0.018	0.014

Notes: The table contains the results of the ordinary least squares regressions for the *Rating in Round t*. The variable of interest is *Period after Fee*, a dummy variable equal to 1 in rounds after a fee is introduced and 0 otherwise. In column 1, we consider all participants who confronted a fee. In column 2, we only include participants who expressed monetary motives. Column 3 includes only participants who expressed fairness preferences. In column 4, participants were confronted with a situation in which they could have earned more money on the other platform after a fee was introduced but did not switch, and in column 5, participants were confronted with a fee and a situation in which they could have earned the same amount or less on the other platform and did not switch. Standard errors are clustered by worker and reported in parentheses. The variable *Completed Tasks AMT* is scaled by #/1,000,000 and the variable *Approval Rate AMT* is scaled by #/100. + $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.4. Channels

	(1) Switching	(2) Switching with Fairness Preferences
Most important self-reported switching motives as a response to fee introduction		
Earn Higher Wages	0.278***	-0.004
	(0.021)	(0.018)
Fee Perceived as Unfair	0.182***	0.052**
	(0.024)	(0.018)
Curiosity	0.152***	0.113***
	(0.023)	(0.018)
Boredom	0.081*	0.091***
	(0.032)	(0.022)
Poor Rating	-0.011	0.033
	(0.031)	(0.022)
Other Reason	0.083*	0.098***
	(0.040)	(0.026)
No Switching	*Baseline*	*Baseline*
Controls		
Average Rating in Round k	-0.077***	-0.068***
	(0.009)	(0.005)
Round k	-0.004	-0.003
	(0.007)	(0.005)
Negative Reciprocity	-0.006	0.016**
	(0.008)	(0.006)
Risk Aversion	-0.021	0.037+
	(0.031)	(0.021)
Risk Ambiguity	0.019	-0.030+
	(0.023)	(0.017)
Completed Tasks AMT	-0.065	-0.033
	(0.100)	(0.075)
Approval Rate AMT	-0.046	-0.060
	(0.089)	(0.060)
Number of Workers	1,349	1,349
Pseudo R^2	0.244	0.245
P=1	38.6%	14.4%

Notes: This table contains the results of the probit regression for switching behavior. The dependent variable in column 1 is a dummy variable that denotes whether the participant switched platforms after the introduction of a fee. In column 2, the dependent variable is also a dummy variable, which takes the value 1 if the participant demonstrated pure fairness preferences by switching after the fee introduction and 0 if participants were confronted with a fee introduction. The coefficients are average marginal effects. The baseline category of the most important self-reported switching motives is *No Switching*. The variable *Completed Tasks AMT* is scaled by #/1,000,000 and the variable *Approval Rate AMT* is scaled by #/100. Robust standard errors are reported in parentheses. + $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.5. Total Wage and Portability Regime

	Total Wage			
	(1)	(2)	(3)	(4)
	All Ratings	Ratings < 3.50	Ratings ≥ 3.50 & < 4.50	Ratings ≥ 4.50
Portability	0.030+	-0.126***	-0.026	0.068***
	(0.016)	(0.044)	(0.034)	(0.015)
Controls				
Risk Ambiguity	0.067***	0.049	0.067+	0.009
	(0.016)	(0.050)	(0.035)	(0.015)
Completed Tasks AMT	0.074	-0.085	-0.001	0.072
	(0.070)	(0.652)	(0.202)	(0.080)
Approval Rate AMT	0.085	0.104	-0.008	-0.031
	(0.073)	(0.100)	(0.110)	(0.078)
Intercept	2.235***	1.892***	2.229***	2.441***
	(0.071)	(0.093)	(0.108)	(0.076)
Number of workers	1,349	122	239	988
Adjusted R^2	0.016	0.055	0.001	0.017

Notes: This table contains the results of the ordinary least squares regressions for total wages. The dependent variable is the *Total Wage* each participant, who experienced a fee, had received by the end of the experiment. In column 1, we consider all participants subject to a fee. In column 2, we consider participants who earned an average rating of less than 3.50 in the final round. In column 3, we consider participants with average ratings greater than 3.50 and smaller 4.50 in the final round. In column 4, we consider participants with an average rating greater than 4.50 at the end of the experiment. The variable *Completed Tasks AMT* is scaled by #/1,000,000 and the variable *Approval Rate AMT* is scaled by #/100. Robust standard errors are reported in parentheses. + $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.7.2 Existence of an incentive-compatible fee

Because it is not possible to find an analytical solution to Equation (3.14), we use hypothetical values of β, f, m_1, h_1, and h_ϵ to find a fee that can fit with this inequality. For a sufficiently low value of β, several periods after the introduction of ϕ on Platform%, the additional discounted value of another completed contract is ≈ 0.

Consider a setting in which the effort cost function is quadratic:

$$g(a_t) = \frac{1}{2} a_t^2(\mathbf{r}_{t-1}). \tag{3.16}$$

Then we can derive an explicit function of both the effort and the labor input in inequality (3.14). Assume the worker stays on Platform%. Following the steps detailed in Section 3.3, we find the first-order condition:

$$\sum_{s=1}^{\infty} \beta^{s-1}(1-\phi)\alpha_{k+s-1} - \beta^{t-1} g'(a_{k+t-1}(\mathbf{r}_{k+t-2})) = 0.$$

Rearranging and assuming quadratic effort costs yields:

$$a_{k+t-1}(\mathbf{r}_{k+t-2}) = \sum_{s=t}^{\infty} \beta^{s-t}(1-\phi)\alpha_{k+s-1}. \tag{3.17}$$

We then look for the equilibrium labor input when the worker switches to Platform#. The first-order condition in this case is:

$$\sum_{s=1}^{\infty} \beta^{s-1}\alpha_s - \beta^{t-1} g'(a_t(\mathbf{r}_{t-1})) = 0.$$

By rearranging and assuming quadratic effort costs, it follows that

$$a_t(\mathbf{r}_{t-1}) = \sum_{s=t}^{\infty} \beta^{s-t}\alpha_s. \tag{3.18}$$

With this explicit form of the effort cost function, inequality (3.14) can be expressed entirely in terms of $\beta, f, m_1, h_1, h_\epsilon$, and ϕ. Figure 3.13 depicts the incentive-compatible fee introduced after four rounds, with some previously established parameters.

Figure 3.13. Incentive compatible ϕ

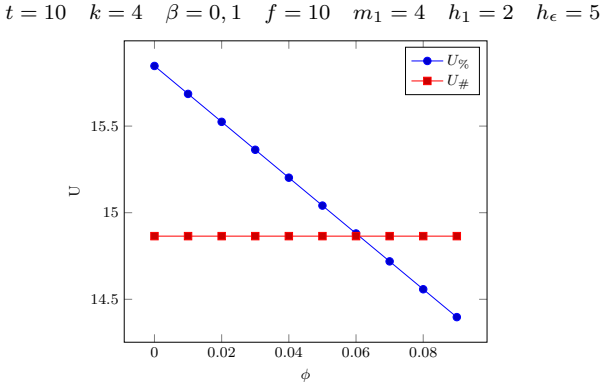


Figure 3.14. Variations of k

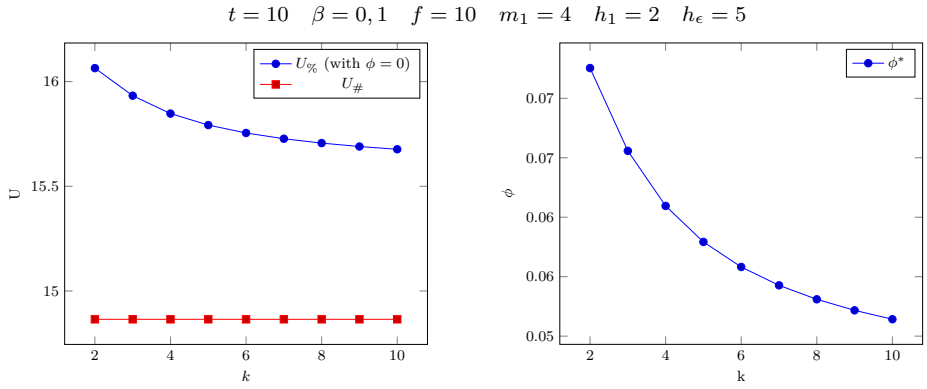


Figure 3.14 then indicates the incentive-compatible ϕ, depending on the time the worker has spent on Platform%. The more time the worker spends on Platform%, the lower the surplus that the platform can extract; this effect is nullified even more when $k \to \infty$ (with the values from Figure 3.14, where $k = 1000000000$, and then $\phi^* = 0.044413846$). The more time workers have spent on the initial platform, the more the market knows about their talent, and the lower the workers' incentive to bias their evaluations. Thus, switching to another platform becomes slightly less unattractive with more time spent on the initial platform.

Figure 3.15 reveals how the difference in utilities between Platform% and Platform# depends on the precision term h_1. A straightforward interpretation of h_1 is that it represents the inverse of the variance of talent η in the market.

We also can interpret it as the precision of the platforms' reputation systems. When h_1 is lower, there is a lower incentive to switch to another platform too. Due to the poor precision of assessments of workers' talent in early rounds, it becomes less interesting for workers to switch, which would require them to start building a new reputation by supplying costly, large amount of labor. Therefore, with lower precision, the platform can impose a larger fee.

Figure 3.15. Variations of h_1

$t = 10 \quad k = 4 \quad \beta = 0,1 \quad f = 10 \quad m_1 = 4 \quad h_\epsilon = 5 \quad \phi = 0$

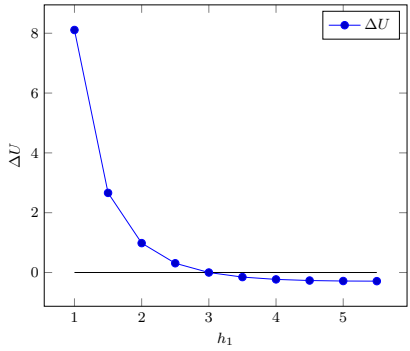
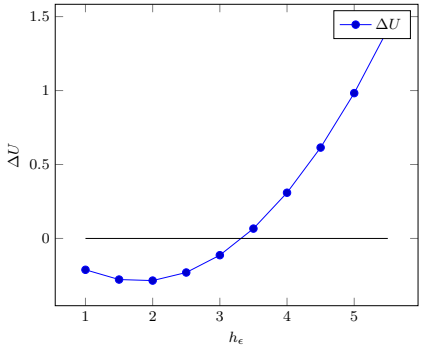


Figure 3.16 indicates the difference of utilities between Platform% and Platform#, according to the precision term h_ϵ. In contrast with the example in Figure 3.15, the incentive to stay on the initial platform is higher when the variance of the noise term is lower.

Figure 3.16. Variations of h_ϵ

$t = 10 \quad k = 4 \quad \beta = 0,1 \quad f = 10 \quad m_1 = 4 \quad h_1 = 2 \quad \phi = 0$



3.7.3 Experimental Instructions

[Note: These are the written instructions, presented to participants in the treatment without reputation portability and asymmetric platforms. Amendments to the other treatment conditions are enclosed in square brackets.]

Instructions

To earn the highest possible amount during this study, please carefully read this introductions page. The study begins immediately thereafter.

Thank you for participating in this study. The instructions will provide you with all the information you require for participation in the study. The instructions accurately reflect how decisions and processes will unfold. We will not deceive or lie to you in any way.

In this study, the duration of your participation will vary between 7 and 10 rounds. Each round has the same structure. From the 7 round onward, a random mechanism will decide whether the study ends or not. After the 7 round, there is a 2/3 probability that another round will take place. At the end of your last round, you will be asked to fill out a questionnaire and will receive your study completion code.

Market Environment

- Imagine a fictitious crowdsourcing market that consists of two online labor platforms, **Platform%** and **Platform#**, and a **requester**. Platform%, Platform#, and the requester are programmed.
- You enter this new market as a **worker**.
- In each round, the requester publishes the **exact** same task on **both** platforms.
- You can perform the task only on **one** platform.
- You can earn money for each task you complete.
- Platform% and Platform# each have an integrated reputation system to evaluate your performance. You will automatically receive a rating for each task you complete.

- Your **earnings** depend on the **average rating** you build up during the study and a possible fee Platform% and Platform# can charge its workers.
- **Platform% and Platform# use an identical reputation system and they have the same payment structure. Platform% and Platform# differ only in terms of how they increase their fees.**
- *[Equal platform treatment condition:* **Platform% and Platform# are perfectly identical: They have the same payment structure, reputation system, and platform fee.**]
- **Your rating is platform-dependent** (i.e., it is stored on the respective platform and cannot be transferred to the other platform). This means that if you have established a rating on one platform and decide to switch to the other, you will need to rebuild a new rating. However, after you have built a rating on a platform, it will be stored on that platform until the end of the study. Thus, if you decide to switch platforms and return to the first platform later on, the rating that you built up before you switched will be stored there.
- *[Reputation portability treatment condition:* **Platform% and Platform# use a cross-platform reputation system.** This means you only have one rating that is applicable for both platforms. As soon as you build a rating on one platform, it will be transferred to and displayed on the other platform as well.]

Details on the payment structure, rating, and platform fees will be provided below.

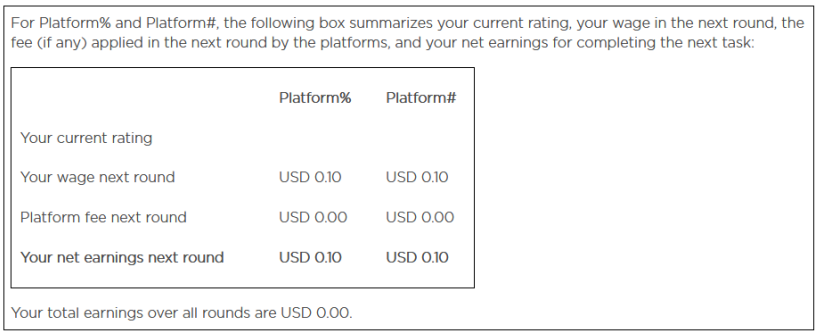
Study Procedure

All rounds follow an identical scheme:

- **Step 1 – Make a decision:** You decide on which platform you want to work during the next round. Registration on a platform is not necessary. You can directly start working.
- **Step 2 – Work on a task:** Your task is to count the number of zeros in a table. Your performances will be rated, and you will receive a new average rating after completing a task.
- **Step 3 – Receive information:** After completing the task, you will be informed separately for each platform about (a) your current rating, (b) your wage in the next round, (c) the fee the platform will charge

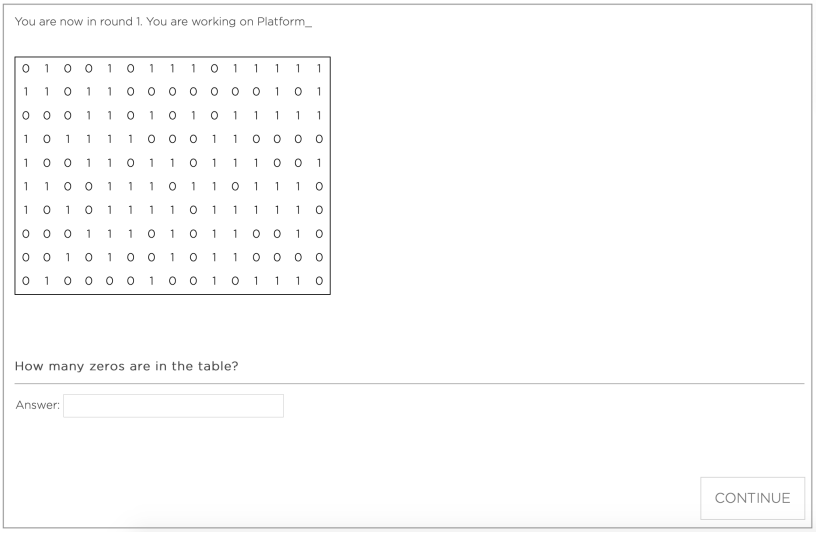
you in the next round (if any), and (d) your net earnings for the task in the next round.

You will receive all necessary information before each round. The information will be shown in a table. The following figure provides an example:



Your Task

Your task is to count the zeros in a table that lists a series of zeros and ones. The following figure shows the work screen you will use later on:



You will always see whether you are currently working on Platform% or

Platform#. Enter the number of zeros into the "Answer" field at the bottom of the screen. After you have entered the number, click the "Continue" button. In each round, you will have only one try to solve the task.

Rating, Platform Fee, and Earnings

In each round, your earnings depend on your rating and whether or not the platform you are currently working on increased its platform fee.

Rating

The procedure for calculating your reputation is identical on both platforms and will result in a rating ranging from 1.00 to 5.00. A rating of **1.00** is given for the worst performance and a rating of **5.00** for the best performance. Your rating in each individual round depends on how accurately you count the number of zeros in the table:

- If you count the **correct** number, you will receive a rating of **5.00**.
- If your counted number differs by +/− **1**, you will receive a rating of **4.00**.
- If your counted number differs by +/− **2**, you will receive a rating of **3.00**.
- If your counted number differs by +/− **3**, you will receive a rating of **2.00**.
- If your counted number differs by **more than +/− 4**, you will receive a rating of **1.00**.

Example: Assume that the correct number of zeros in a table is 10. You counted 9 zeros (i.e., you miscounted by 1). This means your rating in that round is 4.00.

Furthermore, platforms will consider your **average rating** (i.e., the average of your past performance across all transactions in the past rounds). That means that each round is important for your next and final payoff. The rating is always rounded to two decimal places.

Example: Assume that you receive a rating of 5.00 in the first round, 4.00 in the second round, and 5.00 in the third round. Your average rating is therefore (5.00 + 4.00 + 5.00) / 3 = 4.67.

Platform Fee

During the study and starting with round 4, the **platforms may charge a fee to its workers**. A fee is introduced with a 1/4 probability by a random mechanism. The fee will be automatically deducted from your earnings per completion of a task. The fee is announced at the end of a round and always takes effect in the next round. After a fee increase is introduced, it will not be reduced in the following rounds.

Earnings in a round

In each round, the **minimum amount offered** for a task is **USD 0.10**. Depending on your rating, however, you can also earn more money in the next round for completing the task:

- USD **0.10** for a rating **less than 3.50**.
- USD **0.15** for a rating **of at least 3.50**.
- USD **0.20** for a rating **of at least 4.50**.

Your net earnings in each round are given by USD 0.10 but increase depending on your rating minus the platform fee (if any). In other words, for each platform, your net earnings are calculated in each round as follows:

(USD 0.10 + increase due to your rating) − platform fee.

In the first round, or the first time you switch to the other platform, you will earn USD 0.10 for completing the task, as you have not yet established a rating.

[*Equal platform treatment condition:* In the first round, you will earn USD 0.10 for completing the task, as you have not yet established a rating.]

Total Earnings

Your total earnings are the sum of your net earnings on both platforms from all rounds plus USD 1 for taking part in this study.

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