ESSAYS IN APPLIED MICROECONOMICS

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Economics – Doctor of Philosophy

2021

ABSTRACT

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Chapter 1: Are There Incentives to Improve the Search Engines in the Age of Information Overload?

Information overload on the Internet creates a natural demand for higher quality search engines. In this paper, I compare the current advertising (indirect) model of search engines financing with the hypothetical paid (direct) model. I find that under monopoly in innovation activities indirect monopolist has much lower incentives to improve the quality than the direct monopolist. Explicit modeling of entry and quality competition in a static framework leads to the conclusion that under the indirect model only one firm could profitably enter producing the minimally acceptable by consumers quality. A dynamic framework predicts more firms entry but only because the firms are colluding against consumers by saving on quality improvement investments. In contrast, under the direct model firms' cooperation leads to higher investment incentives since it permanently raises industry profit flows. I suggest several alternative policy recommendations to improve incentives in this market.

Chapter 2: Strategic Control and Exclusivity

This paper extends Hagiu and Lee's (2011) "Exclusivity and control" article by making control regime over content in addition to exclusivity as the strategic choice in an industry characterized by a severe platform competition first for content and then for consumers. Under the assumption of homogeneous content valuations, the following results are obtained. First, for low and medium levels of content valuation, there are only affiliation equilibria (both exclusive and multihoming and the latter maximizes industry profit). For the high level of content valuation, there are one exclusive outright sale and multiple affiliation multihoming equilibria with the latter maximizing the industry profits. Finally, there are additional platforms' pessimistic expectations equilibria

under affiliation regime that give higher payoffs to content providers. Implications for business strategies are presented.

Chapter 3: Long Term Effects of Minimum Drinking Age Laws on Organ Failure [1]

Organ failures are among the leading causes to deaths and the most expensive medical procedures in the United States. Medical literature has established the association between alcoholism and chronic dysfunction of organ systems. This paper provides the first causal evidence of the long-term impacts of increasing the MLDA to 21 in various states in the 1970s-1980s on reducing organ failures. By delaying exposure to alcoholic beverages, the MLDA 21 likely limits adolescents' exposure to alcohol and reduce the likelihood of alcoholism in adulthood and thus the risk of alcohol-related diseases, including organ failures. We find that cohorts exposed to higher MLDA (=21) had lower probability of having organ failures in later life. The empirical findings show that limited access to spirits and alcohol before the age of 21 reduced the demand for transplants by 86 and 50 per 100,000 population, respectively, after ten years, given that the average transplants demanded by the cohort prior to treatment is approximately 155. These findings have important implications for evaluating the benefits of the MLDA21 legislation. Besides preventing traffic fatalities, the MLDA21 has significantly reduced organ failures in adulthood, therefore might have increased productivity and life quality of the generations who were growing up in the presence of this legislation.

[1] co-authored with Dr. Minh Nguyen (Department of Economics, Ball State University).

ACKNOWLEDGEMENTS

I would like to thank my supervisor Jay Pil Choi for encouraging me to do original research that applies to the real world, for demonstrating how to read and solve numerous papers in microeconomics. I appreciate your continued support and helping me when I needed it.

I would like to thank Andrei Shevchenko for your help in getting to a Ph.D. program in the US, and for your continued support and help during my studies at Michigan State, for our great philosophical discussions.

I would like to thank Aleksandr Yankelevich, who served on my committee while he was affiliated with MSU, for all the time he devoted to reading and making comments for my drafts, providing great motivating examples, and very personal enthusiastic attitude toward me, helping me to do original research.

I would like to thank Arijit Mukherjee for teaching me how to write an actual draft of the paper and teaching me microeconomics, it helped me not only in research but also in teaching.

I would like to thank Thomas Jeitschko for his interest and numerous comments and suggestions on how to improve and communicate better my ideas, the value of working in teams. I benefited from being his teaching assistant in microeconomics theory at AEASP summer program helping students from underrepresented groups to enter Ph.D. programs in economics. His explanations of solving quality competition games were great and helped in my research.

I would like to especially thank Minh Nguyen with whom we continually worked during my academic training at Ball State and who is the co-author of my empirical chapter. Thank you for all your time, and continued belief in our project's success. Working with you was similar to having a great internship in empirical methods, thank you for all the resources that you shared and provided to me. Most importantly, though, I value our great teamwork on the project, many common values, I think, that helped us to accomplish the project in such a short time. Thank you for being not only a co-author and committee member but also a friend.

I would like to thank Todd Elder for being a great teacher of empirical labor economics, a great director of graduate studies who supported me in getting an internship at CSTAT, a great statistical consulting department at Michigan State, which helped me to improve my empirical skills significantly, as well as for helping me to find a job at Ball State University to teach business statistics. Given how busy he is, I really appreciated his and Thomas Jeitschko's support in helping to add Minh Nguyen to my committee, being enthusiastic about our research questions, and giving great comments for potential future research directions.

I would like to especially thank Jeff Biddle, Steve Woodbury for their quick and very informative response on helping to find historical data on unemployment, alcohol statistics, and other important variables. Jeff Biddle was so kind to consult me via Zoom on our empirical project and provided very valuable feedback which was incorporated in the text of Chapter 3. That was great support and made us much more confident. I want to thank John Goddeeris for introducing me to health economics and connecting me to his great Facebook group on health economics.

I would like to thank MSU Economics Department office manager Margareth Lynch (who recently retired) for her kind support during my job market, our former graduate secretary Lori Jean Nichols and current graduate secretary Jay Feight for their great work in supporting graduate students.

I want to thank Elaine Nelson, a Ball State University librarian, who helped me to receive numerous historical documents about the alcohol industry using inter-library loans. Her devotion to helping me getting great data was amazing and inspired me very much.

I would like to thank Economics Department at Ball State University, especially Philip DeCicca and John Horowitz, for their continued support during academic training at Ball State, encouragement to defend my Ph.D.

I want to thank Stephen Ferris, the Dean of Miller College of Business at Ball State University, for his personal sympathy to me, interdisciplinary perspective, and encouragement to get Ph.D. and publishing papers. More importantly, I learned a lot about different countries and the United States culture by joining his regular lunches during the Covid-19 pandemic.

I want to thank the Higher School of Economics (HSE) and the New Economic School (NES) for giving me the necessary background to enter and successfully receive Ph.D. in Economics. I am especially feel obliged to Kirill Sosunov (my master thesis advisor at HSE), Lev Lyubimov (who recently passed away), Dmitry Levando, Sergey Pekarski, and all teachers and students with whom I interacted at HSE and NES. Thank you Alexei Savvateev for teaching me mathematics like nobody ever did, for showing the beauty of mathematics.

I want to thank the team at Skolkovo Institute for Emerging Markets Studies, Bill Willson (who passed away in 2017), Sam Park, Meng Zhao, Nan Zhou, who played an important part in motivating me to pursue Ph.D. degree.

I would like to thank Søren Johansen, a great statistician of our times and a very nice person, whose class I had the chance to take during the summer of 2008. His advice and methods expanded my appreciation of statistics.

I want to thank my Russian and Thai family for your continued support and for believing in me. I want to thank my Father Volodya, who passed away because of lung cancer in 2015, who always believed I can succeed in my studies and research, who was very bright in mathematics, taught me how to drive a car, and devoted many hours to help me during my college studies. I want to thank my Grandfather Melis, who passed away in 2016 because of dementia, and who was a person of great humor, responsibility for his family, and energetic person, who worked in the mining industry and traveled across all Soviet Union and internationally too, was truly social, loved sports and politics. I want to thank my Mother Olga for her heroic devotion to our family, her love, and her deep attachment to me. I want to thank my wife Noon for your love, pushing me to achieve more, for making and sharing a lot of great photos, and traveling together. I want to thank my Uncle Vanya (a poet Meister Janus) for helping me to make the right decisions in life, helping me to be a good person, and helping me to become one of the best students in class in high school. I want to thank Grandmother Luda for her love and for praying for me and all our family all the time. I want to thank the Mother and Father of my wife, Khon, and Peak, for their love and support. This dissertation is our mutual achievement!

I would like to thank my classmate Andy Chou, and friend Brian Payne who I met while being at Michigan State, I was lucky to meet you guys. I would like to thank numerous friends and people I have met in Russia, Thailand, and United States, and other countries I visited. Thinking of you gives me hope for the future of humanity.

May The Force Be With Us!

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CHAPTER 1

ARE THERE INCENTIVES TO IMPROVE THE SEARCH ENGINES IN THE AGE OF INFORMATION OVERLOAD?

1.1 Introduction

With the introduction of the Internet, the amount of information that consumers observe has increased significantly and continues to rise every day. According to statistics[1] every 60 seconds 571 new websites are created on the Internet, 347 new blog posts are made on WordPress, 72 (400) hours of video are uploaded on YouTube, 41 thousand of new posts appears on Facebook, 278 (350) thousand tweets are made on Twitter, 3600 (65000) photos are uploaded on Instagram and 14 new songs are uploaded on Spotify. In addition in 2017 every 60 seconds 50 new reviews appeared on Yelp.

In order to process this vast and constantly increasing amounts of information, individuals use search engines. Internet Live Stats documents that about 2.6 billion searches are made on Google daily. Since the human ability to process such a vast data is limited, and the data quality varies, hence, there is a natural demand for the better search engines helping to organize and certify this data for the consumer. The importance of the search engines is not just confined to the search engine market itself, search engines potentially affect the efficiency of the whole economy, being an essential infrastructure for the New or Information-based economy.

In this paper, I study the incentives of search engines to improve the quality of their algorithms assuming there is a significant demand for quality improvement by some consumers. I focus on the critical feature of this market that consumers obtain the search engine service for free, but they generate significant advertising revenues used to finance the creation of the search engine service for consumers (I call it an indirect business model). I ask is it possible that such an indirect business model creates an obstacle to the quality improvement incentives? Under what conditions such an

[1] See Woollaston (2013) and updated versions of statistics for 2017 (see go-globe.com (2017)) is shown in parentheses whenever available.

obstacle may happen? How could the market structure affect the outcome? What market structure is predicted for such an indirect business model? I compare the outcomes of the indirect model with a hypothetical scenario when the search engine producer could only charge consumers directly for its service (I call this the direct model).

First, I find (in Proposition 1) that an indirect innovator monopolist chooses the minimally acceptable quality for consumers (such a quality that makes consumer indifferent between using the search engine at zero price or to use the outside option) and makes the service free. In contrast, the direct monopolist creates a higher quality and charges a higher price.

The reason why the indirect monopolist creates lower quality than the direct monopolist is that it could not be compensated by charging a higher price for higher quality without losing significant advertising revenues due to reduced participation by the less willing to pay for quality consumers.

Second, I find (in Proposition 2) that the static or one-shot (interpreted as the long-term competition when firms commit to long-term quality improvement directions) quality competition between equally able innovator search engines leads to the significant quality improvements but completely dissipates expected profits. Hence, such competition does not occur in equilibrium since only one firm enters the market in the indirect model and produces the minimally acceptable quality for consumers. In contrast, the direct model predicts much higher quality and the number of entered firms depends on the degree of income/tastes heterogeneity of the more willing to pay for higher quality consumers.

The intuition why only one firm enters in the indirect model under static quality competition is the following. Since in the indirect model the service is free for consumers, then the firm that produces higher quality attracts all consumers, and given that each firm could always increase its quality a bit higher even if it is costly to do so results in a severe quality competition completely (in expectations) dissipating all ad revenues. As a result, it is never profitable for both firms to enter the market since they could not cover the positive entry costs.

Third, I find (in Proposition 3) that the dynamic quality competition generalizes the static quality competition when the time required to innovate is long enough. Also, the dynamic framework revelas that in cases when the time required to innovate is relatively short, both firms enter, and the Pareto best (from the firms perspective) equilibrium represents collusion on creating the minimally acceptable quality. In contrast, under the direct model, firms cooperate on prices and create much higher than the minimally acceptable quality since such investments raise permanently the industry profit flows.

The intuition of potential collusion on quality is the following. If the time required to innovate is not long enough, then firms could use investments in quality improvement as an instrument of the punishment. Since the time required to innovate is not long enough, then the deviation by increasing the quality above the collusive level would raise the profits only temporarily till the moment when the rival will respond with a punishing war on quality. The punishment is a credible strategy since charging the maximum quality guarantees winning in this market with a zero net profit.

Fourth, in the discussion section of the paper, I show (in Proposition 4) that taking the search engine market for consumers in isolation from the rest of the economy results in the following welfare comparison. The total welfare of the indirect model is always lower than of the direct model. Consumer welfare comparison depends on the assumptions regarding the outside option value and the degree of heterogeneity of type 1 consumers. For example, if the outside options are different and depend on the willingness to pay for the search engines, then the minimally acceptable quality predicted by the indirect model does not make any consumers better than the outside option, so the consumer welfare is the same as for the outside option. I also show how the model could be extended to take into account the externality that the quality of the search engines creates for the other markets of the economy leading to potentially very significant additional welfare losses from the indirect model.

Fifth, in the discussion section of the paper I show (in Proposition 5) how to justify the important assumption that each search engine produces only one service (i.e., could not second degree price discriminate different types of consumers supplying different quality-price options) by introducing the quality spillovers (or "search results scraping") to the inferior alternative rival. I find that in the presence of the significant but still partial spillovers it is profitable to enter by an inferior alternative firm with the hope to attract some loyal consumers through a minor horizontal differentiation and spillovers absorption. Such an entry significantly reduces the profitability of introducing a premium paid service in addition to the basic free service since the premium higher quality service reveals higher quality search results to the rivals who could use it in the main basic market to steal significant advertising revenues. In contrast, under the direct model, spillovers do not play such a role since either the inferior alternative firm does not have enough differentiation to enter the market or since the entering firms could cooperate on prices internalizing spillovers.

In conclusion, I discuss several alternative policies that could cure or relieve the incentive problems identified above. The best way this market to be organized is to make search engines using the direct model. It does not mean that the advertising should be banned. It means, though, that the search engine function and advertising functions should be served by the independent entities. In this case, the consumer will pay directly to the search engine producer for the service and may choose whether to participate in the advertising platform by sharing its search history and providing attention. In case a person agrees to participate, then she receives the price for purchasing her information and her attention while using the search engine. An alternative scenario would be replicating the iPhone and Android industry conditions where iPhone does not have access to significant advertising revenues and have to use direct model creating significant innovation incentives, while Android having significant indirect revenues makes its product much cheaper or more accessible.

1.2 Literature Review

The founders of Google, Sergey Brin and Larry Page, in their paper describing the key initial innovation of Google, Brin and Page (1998), in Appendix A: Advertising and Mixed Motives, discuss three examples of mixed motives (or biases) that an advertising-based business model could have. The first example is a search for a cellular phone, where a consumer may want to see the search results explaining the risk of driving and using the cellular phone at the same time, while the sellers of the cellular phone would be just interested in selling the phone to the consumer. The second example is related to biasing results to the favorable websites ("friendly" companies) away from competitors and to the possibility of such behavior due to the difficulty even for the experts to evaluate search engines. The third example is a situation when some well known (for example the airline) company has to pay for the advertising on a search engine (and hence incur an economic loss) since the advertising based search engine would not have an incentive to show the link to the company's website in its organic links. Also, they point out that not all ads may create such adverse mixed motives, for example, advertisers may compete for consumers through advertising or advertise something that is genuinely new. More generally, they proposed the idea that the better is the search engine from the consumer point of view, the fewer advertisements needed to find what they want and hence higher quality search engines eventually would erode the advertising business model. The authors conclude "But we believe the issue of advertising causes enough mixed incentives that it is crucial to have a competitive search engine that is transparent and in the academic realm."

The three examples of mixed motives are very important and the second example is very similar to the accusation of FTC and European Commission related to Google's practice of biasing results in favor of its services. The idea proposed in this paper, although also related to the incentives misalignment due to the presence of the advertising business model, is different. In all three examples above it is assumed that the search engine already knows how the organic and sponsored links should be ideally (from the social point of view) implemented. Hence, the lack of transparency (or asymmetric information) is the principal obstacle to discipline (either through reputation costs or government sanctions) the search engine against biasing under the advertising based model.

In this paper, I study the role of advertising model for the incentives to create better information about the websites in the first place. I focus attention on the incentive problems that an advertising-based monopolist (or a colluding group of search engines) might have when the potential and the need for quality improvement for consumers is almost unlimited in the age of information overload.

A closely related paper is by Spence (1975) who compares, in my terminology, the direct monopolist's private incentives to create quality with the socially optimal incentives. He finds that if the monopolist could not price discriminate, then it may either overinvest or under-invest in the quality improvement depending on the comparison of the willingness to pay for the quality by the marginal consumer with the average consumer. In particular, if the marginal consumer's willingness to pay for higher quality is lower than the average willingness to pay, then the monopolist would under-invest in quality from the social point of view. In this paper I suggest that the fact that the price in the search engine market is zero might indicate that the indirect model's marginal consumer has much lower willingness to pay that the direct marginal consumer analyzed by Spence. Hence the quality distortion is more severe under the indirect model than under the direct model. Moreover, the public good nature of the search engine and resulting externalities from the search engine to all other sectors of the economy creates additional welfare loss (gain) from lower (higher) quality search engines.

White (2013) analyses a situation when consumers use a search engine to buy products, and hence he proposed a model of a monopolist search engine which intermediates between merchants and consumers. The search engine is assumed to be free for consumers (but they have to pay for the products bought) and merchants are charged a fee for participation. By changing the fee, the monopolist may regulate the number of merchants in the market and hence the prices (the more merchants there are, the lower are the prices) which affects consumer participation decision. It is assumed that in order to search consumers have to incur a search cost. Moreover, if they search, then the willingness to pay for the product is not affected by the search engine's quality. Search engine's quality could only reduce the cost of search and hence increase the participation by consumers. Increased participation by consumers may either reduce or increase the price charged by merchants, and the corresponding conditions are derived. Hence, higher quality may lead either to an increase or a reduction of the monopolist's profits extracted from merchants. In an extension, it is shown that if the search engine also provides organic results, then the higher quality increases the number of merchant shown in the organic results, and, then, the increased competition by merchants dissipates profits to be extracted by the monopolist search engine. Hence, the monopolist does not have an incentive to improve the quality too much.

Taylor (2013) studies a situation of competing in quality search engines and studies the relation between the search quality and revenue cannibalization. The author explicitly models the choice between organic search results and sponsored search results. Revenue cannibalization happens when higher quality organic search results attract more attention of consumers than the sponsored links. He finds that even if it is costless to produce quality, there is an upper bound on the quality above which competing search engines will not improve the quality.

Burguet et al. (2015) examines the incentives to provide reliable search results of a monopolist search engine funded by advertising. The authors provide microfoundation to the substitution effects between organic and sponsored search results. It is assumed that consumers search for content in organic search engine while they search for products at the sponsored search engines. The key trade-offs are the following. Higher quality for consumers of both organic and sponsored results attracts consumers to use the search engine. On the other hand, better organic results quickly divert consumers to publishers websites, and if the organic search is of higher quality, then publishers could easily target ads, and hence consumers will demand less sponsored search results. Given the identified trade-offs, the proposed model allows analyzing the welfare effects of integration between the search engine and a small fraction of content providers.

Etro (2021) compares a device-funded platforms, like Apple's iPhone, with ad-funded platforms, like Google's Android, and finds that incentives of a device-funded platform in setting commissions on external apps and providing its own apps are largely aligned with those of consumers and much less aligned for the ad-funded platform. This is similar to what I find in respect of the higher alignment of incentives of directly funded search engines models as compared to indirectly or ad-funded model. As I remark in conclusion of my paper, iPhone and Android hybrid, paid and ad based, model could be considered as potential direction in which search engine market can converge if higher-quality paid search engines will be introduced at some point in the future.

The papers by White (2013), Taylor (2013), and Burguet et al. (2015) all focus on the bias that happens within the indirect model assuming that there is competition between organic search results quality and sponsored search revenues. In particular, the cannibalization bias happens if the advertising revenues depend negatively on the search engine quality[2].

In contrast, the indirect monopolist distortion identified in this paper may exist independent of whether there is cannibalization effect between sponsored links and organic links since in the direct model all links are organic. Moreover, the quality improvements I am referring in my paper are of a more medium to long-run nature when a search engine can improve both organic results quality as well as sponsored results quality which would prevent the cannibalization effect. On the other hand, advertising revenue in practice consists not only from the search ads, but the ad revenues that a search engine may create at other platforms owned the dominant search engine (for example, Google advertises on YouTube, Android Play Store, and any Internet websites participating on AdSense platform) and which may be to much less extent subject to the cannibalization effect.

1.3 Stylized Facts About the Internet Search Engine Market

The following stylized facts on the internet search engine market are worth noting. First, according to the Internet Live Stats (2018) in June 2017 there were about 1.8 billion websites on the Internet with an annual growth of 69% as compared to June 2016. For comparison, there were about 29 million websites on the Internet in June 2000. Hence, on average the number of websites on the Internet grew 35% annually over the last two decades.

As another comparison, there was only one website in 1991 and the average annual growth rate of the number of websites on the Internet was 753% during the period from 1991 till 2000.

Hence, these figures suggest that there may be a significant demand for higher quality search engines in order to be able to use this vast amounts of information efficiently.

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[2]White (2013) considered the possibility of a positive relationship between the sponsored revenues and sponsored search engine quality. In his framework, higher quality may raise the monopoly power of the advertising firms resulting in more ad revenues extracted by the search engine. This effect depends on the parameters of the model, and if certain conditions are not satisfied, then the opposite effect may occur.

The proposed idea is interesting, but it fits better online retailer context like Amazon than the Internet engine where consumers search for information not necessarily with the intention to buy something. The value of such information could not be internalized through the advertising revenue.

In 2012 Pew Research Center (see Purcell et al. (2012)) published the results of a survey conducted from January 20-February 19, 2012 among 2,253 adults age 18 and over, including 901 cell phone interviews. They were asked about the different experiences they have had using search engines. They said that in their use of search engines they had:

- Learned something new or important that really helped them or increased their knowledge (86% of search users have had this experience)
- Found a really *obscure fact* or piece of information they thought they would not be able to find (50%)
- Gotten *conflicting information* in search results and not been able to figure out what is correct (41%)
- Gotten *so much information in a set of results that you feel overwhelmed* (38%)
- Found that *critical information is missing* from search results (34%)

Also in this survey, the searchers were asked: "*How confident* do you feel about your own searching abilities when using a search engine to find information online?". Just over half of search users (56%) say they are very confident in their search abilities. Another 37% of search users today describe themselves as *somewhat confident*, with fewer than one in ten saying they are not too or not at all confident in their ability to use search engines to find information online.

Hence, this survey indicates that consumers find the current search engines helpful but there is room for improvement. To summarize, the first stylized fact states that the amount of information on the Internet has significantly increased and is projected to rise further creating a natural demand for higher quality search engines. Moreover, consumer surveys indicate that there are important areas for potential improvement of the current search engines quality.

Second, historically, Internet search engines never charged consumers positive prices and provided their services for free to consumers. Search engines' profits resulted from charging advertisers for showing their ads to consumers of the search engines.

Third, according to StatCounter (2018) as of September 2018 worldwide desktop search engine market share of the top-5 search engines were the following: Google 89.12%, Bing 4.25%, Yahoo![3] 3.15%, Yandex 1.4% (including both Yandex Ru and Yandex), Baidu 0.61%. The current market shares have not changed much for the available data from 2009 till 2018 with the following average market shares: Google 89.4%, Bing 4.0%, Yahoo! 3.5%, Yandex 0.8% Baidu 0.6%.

The information on the US market is a bit ambiguous. According to ComScore in February 2016 the desktop market shares of search engines were: Google 64%, Bing 21.4%, Yahoo 12.2%. In contrast, Statcounter gives the following numbers: Google 79%, Bing 11%, Yahoo 8%.

If the languages define the search engine markets, then in most of the countries of the world Google has a market share of about 90%. The exceptions are China, Czech Republic, Russia and South Korea in each of which there is a local competitor with a significant average for last 10 years market shares: Seznam in the Czech Republic (16%), Baidu in China (70%), Yandex in Russia (45%), Naver in South Korea (32%). It is notable that the above search engines dominating or dominated at some point their local markets in a similar way now Google dominates in the world.

Despite the last decade's significant dominance of Google, in the 90s the search engine markets in the US and other countries of the world were characterized by much less concentration, more symmetry in the sizes of key players, more often entry/exit as well as much larger number of independent (i.e. not powered by others) search engines (see Gandal (2001)).

Fourth, there always existed (although much less during the last decade) free lower quality search engines which have very low market shares. Currently, such search engines attract consumers through a certain horizontal differentiation feature (privacy concerns, loyal consumers from 90s when these search engines were among the leaders).

Fifth, there were instances when one search engine scraped the search results from the other search engine. One instance of such copying was identified both by FTC and European Commission[4] when it was found that Google used without consent the original content from third party

[3]Currently Yahoo!Search on the desktop computers is powered by Bing, mobile search is powered by Google, while the local search is powered by Yelp (see Wikipedia (2021)).

[4]See European Commission (2013) and Rosch (2013)

websites (like consumer reviews from Yelp, TripAdvisor, Amazon and news publishers) in its own specialized web search services.

Another potential[5] instance of scraping or copying of search results was revealed by Google in 2011. Google, in order to check if Bing was using Google's search results to improve its results, asked its engineers to show random results on their website for some rare search terms with intentional misspellings. Google stated that it observed that those results appeared soon on the Bing.

It should be noted that although I have presented only two instances when scraping was observed (or claimed to be observed) but it does not preclude that such a copying happens on a regular basis in a way that is difficult to identity that actual scraping has happened.

1.4 Baseline Description of the Model

Information overload is referred to a situation when the increase in the amount of available information on the Internet is not accompanied by the adequate increase in the search engines quality, preventing the efficient use of all existing information in the process of consumption and production.

Even though the Internet search engines are so crucial for the economy as a whole, the quality of the search engines is determined primarily in the search engine market itself. Hence, to predict the quality of search engines it suffices to focus on the partial equilibrium analysis of the search engine market per se. However, the welfare analysis of the search engine quality could not be made appropriately without taking into account the positive (negative) externality that the higher (lower) quality search engines create for other markets and activities in the economy. I will return to the discussion of welfare at the end of the paper.

In this paper, I propose a model of Internet search engine market that explains the key stylized fact of this market that the price of search engine service is zero. I find that such a model does not create enough incentives for Internet search engines to improve the quality contributing to

[5]First, see CNN Wire (2011). For a second opinion, see Foley (2021)

the problem of information overload. In particular, the current Internet search engine market is characterized by the presence of the significant advertising revenues that consumers bring to the search engine[6]. I call such a situation *the indirect model*. The game under the indirect model is described as follows.

Players

There are three types of players.

1) Consumers of search engine services

2) Advertisers

3) Producers of search engines

Players objectives (Payoff functions)

1) Consumers maximize the utility from using search engines.

2) Advertisers maximize profits from buying ad space at the search engines.

3) Search engines maximize the sum of payments by consumers and advertisers net of investment in quality costs.

Players choices/strategies

1) Consumers make consumption decisions in the search engine market.

2) Advertisers make participation decisions in the search engine advertising markets.

3) Search engines are choosing whether to enter the market, which quality to create and which price to set to consumers and advertisers.

The direct model is a hypothetical situation on the Internet search engine market where search engine producers could only charge consumers directly and hence the advertising revenues do not affect the incentives of the search engine producer. Hence, the direct model game will have only two players: consumers and search engines. The full description of the direct model is the following.

[6]The current search engine market is usually considered as a special case of a two- or multi-sided market (See Rochet and Tirole (2003) and Armstrong (2006)), when platforms serve two or more distinct groups of customers, and each group's presence affects the other groups. Such a description is incomplete for the search engines market where the search engine itself creates a critical complementary value for consumers and the economy by organizing and certifying all existing information on the Internet.

Players

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2) Search engines are choosing whether to enter the market, which quality to create and which price to set to consumers.

Next, I will give a more detailed description of each type of players in the search engine market.

I assume that the amount of information on the Internet is so high that there is a group of type 1 consumers whose marginal willingness to pay for quality, θ_1, is high[7]. But if all consumers had a high willingness to pay for the quality improvement in this market, it would be difficult to explain the key stylized fact that the price for consumers was historically zero in this market. Hence, I assume that there are type 2 consumers whose willingness to pay for better quality, θ_2, is very low ($\theta_2 < \theta_1$), however they prefer higher quality too. The total number of consumers in the market is N consisting of n type 1 consumers and $N - n$ type 2 consumers.

Type $i = 1, 2$ consumers choose whether to use search engine service or not (and if to use, then which one) by comparing its consumer surplus from different options. In particular, the consumer surplus is $CS(\theta_i) = \theta_i s - p$ for $i = 1, 2$.

[7]Underlying this willingness to pay for the search engines are the following essential needs:

1. The need for help in organizing vast amounts of information due to human cognitive limitations which results in the reduction of the search costs.

2. The need for information certification.

3. The need for exclusive online information that is not available offline (blogs, reviews, online news, personal, governments and companies' websites, etc.).

I assume that there is a minimally acceptable level of quality, $s^{MA} > 0$, below which type $i = 1, 2$ consumers will choose the outside option with the value $r = \theta_2 s^{MA}$ (I assume, for simplicity, that the outside option is the same for both types). The value of the outside option, r, is interpreted as the value of information that consumers may obtain from alternative sources such as inferior alternative search engines available on the Internet as well as traditional sources like TV, radio, newspapers or communicating with friends, etc. In the discussion section I consider an extension where the quality of the outside option will be determined by the inferior alternative search engine and could be higher than the s^{MA} since there is a search engine quality spillover from the innovator producers to the inferior alternative search engines. In the search engine industry's jargon such a practice is called the "scraping" or copying of search results.

Finally, I assume that advertisers do not harm or benefit consumers in any way, the externality of advertisers on consumers is zero. It means that the welfare analysis of my model does not include any negative or positive externalities that advertisements may exert on consumers. In contrast, the main focus of the paper is on studying search engines incentives to improve quality in the presence of the opportunity to earn significant indirect revenues through advertising.

The number of advertisers is normalized to 1. On average each consumer generates a positive externality on each advertiser of the size $\alpha > 0$. Such an externality represents additional sales revenues that firms receive by posting their ads through the search engine's ad platform. For simplicity, it is assumed that this externality is constant for all consumers and all advertisers. Advertisers prefer to post ads on all platforms to achieve the maximum possible audience, i.e. they multi-home.

A search engine producer maximizes its profit by chooses the quality level s, the price paid by consumers, p, and the price paid by advertisers, d. In order to choose the quality level s, the monopolist invests the sum $c(s)$ with $c'(s) > 0$, $c''(s) > 0$, $c(0) = 0$. For simplicity, I assume a quadratic investment cost function, $c(s) = \frac{1}{2\gamma}s^2$, where γ is the parameter of technological progress in the search engine industry.

Figure A.1 and A.2 summarize key assumptions of the model and parameters affecting the choice of price and quality by the search engine.

1.5 Benchmark: Monopoly in Quality Investments

Consider a situation when there is a monopoly in quality investments. In other words, there is only one firm capable to innovate in this market. First, I will describe how the demand is formed and then I will formulate the monopolist's problem. Type 1 consumers will use the service of the quality monopolist firm if

$$\theta_1 s - p \geq r \text{ and } s \geq s^{MA},$$

while type θ_2 consumers will use the service of the quality monopolist firm if

$$\theta_2 s - p \geq r \text{ and } s \geq s^{MA}.$$

Hence, the demand function faced by the monopolist is

$$Q = \begin{cases} n & \text{if } \theta_2 s - r < p \leq \theta_1 s - r,\ s \geq s^{MA} \\ N & \text{if } 0 \leq p \leq \theta_2 s - r,\ s \geq s^{MA} \\ 0 & \text{if } 0 \leq s < s^{MA} \end{cases}.$$

Consider the indirect model first.

The indirect monopolist's problem is

$$\Pi^{ID} = \max_{p,s} \left\{ Q\left(p + \alpha\right) - \frac{1}{2\gamma} s^2 \right\}.$$

Notice, that for any $s : 0 \leq s < s^{MA}$, the maximal profit is zero, $\Pi^{ID} = 0$. Hence, the monopolist would choose $s \geq s^{MA}$ only if it would result in a positive profit. Let me assume this condition, $\Pi^{ID} > 0$, and later to check if it is true.

The monopolist's problem is for a given level of quality to choose whether to charge the low price and to attract both types of consumers or to charge the high price and to attract only type 1 consumers. And then to choose the optimal level of quality investment. This problem could be reformulated in the following way

$$\Pi^{ID} = \max\left\{\max_{s,p}\left[n\left(p+\alpha\right)-\frac{1}{2\gamma}s^2\right];\ \max_{s,p}\left[N\left(p+\alpha\right)-\frac{1}{2\gamma}s^2\right]\right\}.$$

Given the demand and quality s, the optimal price for the first argument of the above expression is

$$p^{IDH} = \theta_1 s - r,$$

while the optimal price for the second argument is

$$p^{IDL} = \theta_2 s - r.$$

Substituting the optimal prices gives

$$\Pi^{ID} = \max\left\{\max_{s}\left[n\left(\theta_1 s - r + \alpha\right)-\frac{1}{2\gamma}s^2\right];\max_{s}\left[N\left(\theta_2 s - r + \alpha\right)-\frac{1}{2\gamma}s^2\right]\right\}.$$

In case when the indirect monopolist decides to charge the high price, the optimal quality choice is

$$s^{IDH} = \theta_1 n\gamma.$$

In case when the indirect monopolist decides to charge the low price, the optimal quality choice is

$$s^{IDL} = \theta_2 N\gamma.$$

Substituting quality choices into the objective function gives

$$\Pi^{ID} = \max\left\{\left(\frac{(\theta_1 n)^2\gamma}{2}-rn\right)+\alpha n;\left(\frac{(\theta_2 N)^2\gamma}{2}-rN\right)+\alpha N\right\}.$$

Denote the first argument of the above expression by $A_1^{ID} \equiv \left(\frac{(\theta_1 n)^2\gamma}{2}-rn\right)+\alpha n$ and the second argument by $A_2^{ID} \equiv \left(\frac{(\theta_2 N)^2\gamma}{2}-rN\right)+\alpha N$.

Hence, the indirect monopolist's choice of prices and qualities will depend on whether the first or the second argument is greater. If the first argument is greater, then the optimal choice is

$$p^{ID} = \theta_1 s^{ID} - r \text{ and } s^{ID} = \theta_1 n\gamma,$$

while if the second argument is greater, then the optimal choice is

$$p^{ID} = \theta_2 s^{ID} - r \text{ and } s^{ID} = \theta_2 N\gamma.$$

I will make the following assumption implying that it is more profitable for the indirect monopolist to charge the low price.

Assumption 1 I assume the following:

(i) $A_1^{ID} < A_2^{ID}$, i.e., $\frac{(\theta_1 n)^2\gamma}{2} - rn + \alpha n < \frac{(\theta_2 N)^2\gamma}{2} - rN + \alpha N$.

(ii) $\frac{(\theta_2 N)^2\gamma}{2} - rN + \alpha N > 0$.

The second condition just states that the profit from creating the quality $s^{ID} = \theta_2 N\gamma$ is positive.

The first condition of the Assumption 1 is equivalent to the following condition

$$\left(\frac{(\theta_1 n)^2\gamma}{2} - rn\right) - \left(\frac{(\theta_2 N)^2\gamma}{2} - rN\right) < \alpha\left(N - n\right).$$

This condition states that the indirect monopolist would prefer to charge the low price and to produce the quality $s^{ID} = \theta_2 N\gamma$ if charging the high price and producing $s^{ID} = \theta_1 n\gamma$ adds less direct profit than losing indirect revenue. Such a condition is more likely to be satisfied when type 2 consumers bring significant indirect revenues, $\alpha(N - n)$ and when it is costly to improve the quality (γ is lower).

Under the Assumption 1 the indirect monopolist sets the following price and quality:

$$p^{ID} = \theta_2 s^{ID} - r \text{ and } s^{ID} = \theta_2 N\gamma \geq s^{MA}.$$

I will make the following assumption which would allow for the model to predict the key stylized fact in the search engine market that the search engines provide their services for free to consumers.

Assumption 2. $\theta_2 N\gamma < s^{MA}$.

Assumption 2 means that type 2 consumers' willingness to pay for the quality is so low that it would not be profitable to create the search engine for type 2 consumers in the absence of advertising revenues that a search engine could earn from attracting type 2 consumers.

Under Assumptions 1 and 2, the indirect monopolist sets the following price and quality:

$$p^{ID} = 0 \text{ and } s^{ID} = s^{MA}.$$

Consider the direct model.

The direct monopolist's problem is identical to the indirect monopolist's problem when $\alpha = 0$. Like in the indirect model, setting the quality level below minimally acceptable level, $0 \leq s < s^{MA}$, results in a zero profit, $\Pi^D = 0$,since consumers do not participate in the market.

Hence, again, I will assume that it is profitable to produce $s \geq s^{MA}$ and later I will check if it is true. Then, the direct monopolist's problem is

$$\Pi^D = \max\left\{\max_{p,s}\left[np - \frac{1}{2\gamma}s^2\right]; \max_{p,s}\left[Np - \frac{1}{2\gamma}s^2\right]\right\}.$$

For a given level of quality s, if the direct monopolist chooses to sell its service only to type 1 consumers, it will set the high price

$$p^{DH} = \theta_1 s - r.$$

If the direct monopolist chooses to sell to both types of consumers, it will set the low price

$$p^{DL} = \theta_2 s - r.$$

Hence, the monopolist's problem becomes

$$\Pi^D = \max\left\{\max_s\left[n\left(\theta_1 s - r\right) - \frac{1}{2\gamma}s^2\right]; \max_s\left[N\left(\theta_2 s - r\right) - \frac{1}{2\gamma}s^2\right]\right\}.$$

The optimal qualities for each of the arguments are

$$s^{DH} = \theta_1 n\gamma \text{ and } s^{DL} = \theta_2 N\gamma.$$

Substituting optimal qualities gives

$$\Pi^D = \max\left\{\frac{(\theta_1 n)^2\gamma}{2} - rn; \frac{(\theta_2 N)^2\gamma}{2} - Nr\right\}.$$

Denote the first argument $A_1^D = \frac{(\theta_1 n)^2\gamma}{2} - rn$, while the second argument $A_2^D = \frac{(\theta_2 N)^2\gamma}{2} - Nr$. Consider the following assumption.

Assumption 3 I assume the following:

(i) $A_1^D > A_2^D$, i.e., $\frac{(\theta_1 n)^2\gamma}{2} - rn > \frac{(\theta_2 N)^2\gamma}{2} - rN$.

(ii) $\frac{(\theta_1 n)^2\gamma}{2} - rn > 0$.

This assumption states that it is more profitable to charge the high price and produce the high quality than to charge the low price and produce the low quality in the direct model. The second part of Assumption 3 states that it is profitable to create the high quality.

When the Assumption 3 is satisfied, the direct monopolist chooses

$$p^D = \theta_1 s^D - r \text{ and } s^D = \theta_1 n\gamma > s^{MA}.$$

The last inequality states that the direct monopolist's quality is higher than the minimally acceptable level and this inequality is guaranteed if the Assumption 3 is satisfied.

The analysis of this section could be summarized in the following proposition.

Proposition 1. *Under Assumptions 1, 2, and 3, the indirectly financed search engine charges lower price, $p^{ID} = 0$, but produces also lower quality, $s^{ID} = s^{MA}$, than the direct monopolist which charges higher price $p^D = \theta_1 s^D - r$ and produces the higher quality $s^D = \theta_1 n\gamma \geq s^{MA}$.*

The main intuition of Proposition 1 is related to the idea of the dilemma which type of consumers to serve by the monopolist given that the monopolist could create only one service[8]. Above proposition is illustrated in Figure A.2.

There are two types of demands for quality improvement: the high demand of type 1 consumers and the low demand of type 2 consumers. Under Assumption 3, in the direct model the reward for the monopolist is directly linked to the demand of type 1 consumers and, hence, the monopolist chooses to supply the quality that would satisfy type 1 consumers' demand resulting in the highest profit. Supplying the quality level to satisfy the less willing to pay type 2 consumers reduces the profit in the direct model.

In contrast, in the indirect model serving the type 2 consumers who have lower demand for the quality improvement is a better option for the monopolist since such types bring significant ad revenues and allow the monopolist to reduce the investment on quality improvements to the minimally acceptable level. Raising the quality above the minimal level and charging higher price would repel type 2 consumers and would lead to the loss of indirect revenue that could not be compensated by the higher direct profit coming from type 1 consumers under Assumption 1. Hence, the presence of significant indirect revenues related to type 2 consumers "breaks the link" between the search engine producer's incentives to improve the quality and type 1 consumer willingness to pay for higher quality. Such a situation is especially harmful in the age of information overload that naturally raises both the private demand of type 1 consumers for higher quality as well as the public demand of the whole society for better functioning search engines.

[8] It is assumed that the monopolist could not second-degree price discriminate by creating two services of basic and premium quality. In the discussion section of the paper, I consider an extended model with spillovers. Quality spillovers could reasonably explain why each search engine produces only one service in this market and captures the stylized fact, presented in the previous section, that the quality spillovers were observed in this market.

1.6 Static Competition for Quality

Proposition 1 has shown that if there is only one firm in the market that is able to invest in search engine quality improvement, then the indirect business model may represent a serious obstacle for the quality improvement. In this section, am looking at the natural counter-argument that competition would allow to overcome or even make the indirect model more attractive than the direct model in terms of search engine quality improvement. Instead of just assuming the quality competition in the indirect model or direct model, I would like to study under what conditions such an intense competition would occur by modeling the entry decision in this market. For that purpose, I am considering a simplest possible static, deterministic quality competition model where at the first stage firms simultaneously choose whether to enter the market; at the second stage firms simultaneously choose the quality of their services; at the third stage firms simultaneously choose prices.

Consider the indirect model.

Let me solve the model by backward induction. Suppose that both firms have entered at the first stage and their competition resulted in $s_j > s_m$ for $j, m \in \{1, 2\}$ and $j \neq m$.

I will assume that it is always optimal for the firm $j = 1, 2$ with superior quality to set the low price such that all consumers are attracted to receive all possible advertising revenues in the market[9]. The following assumption captures this idea.

Assumption 4. $\theta_1 \left(s_j - s_m\right) n + \alpha n < \theta_2 \left(s_j - s_m\right) N + \alpha N,$

where firm $m = 1, 2$ represents the inferior quality firm and $j \neq m$.

Moreover, to simplify the following analysis of quality competition, I will consider an extreme assumption that type 2 consumers are not willing to pay for higher quality at all, although they would choose higher quality search engine if all search engines are free.

[9] If Assumption 4 is not satisfied, then it would be possible to have an equilibrium of the whole game under the indirect model where both firms enter with one firm creating a premium paid service while the other firm creating a free service of minimally acceptable quality. I do not focus on such an equilibrium since it does not satisfy an important stylized fact for the Internet search engines market that historically paid Internet search engines never existed.

Assumption 5. $\theta_2 = 0$.

Assumption 5 simplifies[10] considerably the analysis of the quality competition below since under Assumption 4 and 5 the firm with superior quality sets zero price of its service independently of its and rival's qualities levels, s_1 and s_2.

Together, Assumptions 4 and 5 imply the following condition

$$\theta_1 \left(s_j - s_m\right) n + \alpha n < \alpha N.$$

Under Assumption 4 and Assumption 5, one can conclude that firms 1 and 2 set zero prices and since firm 1 has higher quality, it wins all the indirect revenues while firm 2 gets zero indirect revenue, i.e.,

$$p_1^{ID} = p_2^{ID} = 0, \ \pi_1^{ID} = \alpha N, \text{ and } \pi_2^{ID} = 0.$$

Consider now the second stage simultaneous quality choice. Firms choose quality levels to maximize their profits. Consider the best response function for the quality choice of firm j to the quality choice by the rival firm m.

$$s_j^* = \begin{cases} s^{MA} & \text{if } s_m = 0 \\ s_m + \varepsilon & \text{if } s_m = \left\{s > s^{MA} : \alpha N > \frac{1}{2\gamma} s^2\right\} \\ 0 & \text{if } s_m = \left\{s : \alpha N \leq \frac{1}{2\gamma} s^2\right\} \end{cases} .$$

The best response functions of quality choices do not intersect. It means that in this game there are no pure strategy equilibria. The only possible equilibria are in mixed strategies.

Let me construct all mixed strategy equilibria. Suppose that firm $m = 1, 2$ plays a mixed strategy represented by the cumulative density function $F_m(s)$ defined on the support $\{0\} \cup [s^{MA}, \overline{s}^{\text{static}}]$

[10] It should be emphasized that qualitatively the analysis will not change without Assumption 5. To get the result that I obtain under Assumption 5 below it is sufficient to use just Assumption 3. Assumption 3 guarantees that the only incentive to improve quality under indirect model is to steal the advertising revenues of the rival and not to earn direct revenue from consumers.

where $\overline{s}^{\text{static}}$ represents a level of quality in a static model when the cost of quality improvement completely exhausts all advertising revenue in the market, i.e.,

$$\overline{s}^{\text{static}} = \left\{ s : \alpha N = \frac{1}{2\gamma} s^2 \right\}.$$

In order for firm $j = 1, 2$ to use a mixed strategy $F_j(s)$ in equilibrium, it should be indifferent between playing any pure strategy in the support of the mixed strategy $F_j(s)$ when the rival firm plays $F_m(s)$. In particular, suppose firm $j \neq i$ plays a pure strategy $s \in \{0\} \cup [s^{MA}, \overline{s}^{\text{static}}]$, then its expected profit (gross of sunk entry costs) from playing any quality $\forall s \in \{0\} \cup [s^{MA}, \overline{s}^{\text{static}}]$ given that the rival firm is playing $F_m(s)$ is

$$E\pi_j(s, F_m(s)) = F_m(s) \left[\alpha N - \frac{1}{2\gamma} s^2 \right] + (1 - F_m(s)) \cdot \left(-\frac{1}{2\gamma} s^2 \right) = E\pi,$$

or

$$F_i(s) = \frac{E\pi + \frac{1}{2\gamma} s^2}{\alpha N}.$$

Any cumulative probability distribution function should satisfy the conditions: $F_j(0) = 0$ and $F_j\left(\overline{s}^{\text{static}}\right) = 1$. The first condition implies

$$E\pi = 0.$$

Substituting $E\pi = 0$ into the second condition gives $\frac{0 + \frac{1}{2\gamma}\left(\overline{s}^{\text{static}}\right)^2}{\alpha N} = 1$ and using the definition of $\overline{s}^{\text{static}}$ it is seen that the second condition is satisfied. Hence, a mixed strategy equilibrium was constructed. Notice, that the obtained function $F_j(s)$ is the only solution and it does not depend on i.Therefore, it was shown also that there is a unique Nash equilibrium with both $j = 1, 2$ playing the following mixed strategy

$$F_j(s) = F(s) = \begin{cases} \frac{1}{\alpha N} \frac{1}{2\gamma} s^2 & \text{if } s \in \left[s^{MA}, \overline{s}^{\text{static}} \right] \\ \frac{1}{\alpha N} \frac{1}{2\gamma} \left(s^{MA} \right)^2 & \text{if } s = 0 \end{cases}, \ j = 1, 2.$$

From the cumulative density function it is seen that If the cost function is convex, $c''(s) > 0$, then the probability density function is always increasing on $[s^{MA}, \overline{s}^{\text{static}}]$, which means that higher quality values (closer to $\overline{s}^{\text{static}}$) are more likely to be drawn than the lower quality levels.

Based on the above analysis it can be concluded that if both firms enter, then firms will use mixed strategies in the unique Nash equilibrium found above and will get the expected profit (gross of entry costs) of zero.

In general, there are three equilibria in the entry stage game (see derivations in the Appendix):

1. A pure strategy equilibrium: firm 1 enters and firm 2 does not enter. Firm 1 produces the minimal acceptable quality and sets zero price.

2. A pure strategy equilibrium: firm 2 enters and firm 1 does not enter. Firm 2 produces the minimal acceptable quality and sets zero price.

3. A mixed strategy equilibrium: firm 1 enters with probability $1 - \frac{K}{\alpha N}$, firm 2 enters with probability $1 - \frac{K}{\alpha N}$. If only one firm enters, then it sets the minimal acceptable quality and zero price. If both firms enter, then the mixed strategy equilibrium in quality studied above follows and firms set zero prices.

The mixed strategy equilibrium predicts that entry by both firms may take place with probability $\left(1 - \frac{K}{\alpha N}\right)^2$. The mixed strategy equilibrium should be considered with suspicion since it would disappear if the entry game is sequential or firms could coordinate their entry decisions.

Consider the direct model.

Suppose that both firms entered at the initial stage. The Assumption 5 and the assumption that type 1 consumers are completely homogenous results in the winner takes all situation at the second and third stages, unless the qualities are the same, but in that case static price competition results in zero profits for the firms. Hence there are three possible equilibria at the second stage: two pure strategy equilibria when firm $j = 1, 2$ creates monopoly quality and sets the monopoly price while firm $m \neq j$ sets its quality at zero; a mixed strategy equilibrium when both firms create monopoly levels with some probability and create zero quality with some probability. As before whenever there are mixed and pure strategy equilibria, I select pure strategy equilibria to be the prediction since mixed strategy equilibria could be ruled out either through sequential moves or some coordination between the firms. Predicting this outcome, only one firm enters in the pure strategy equilibrium (as in the indirect model, there is a possibility of the mixed strategy equilibrium at the entry stage when both firms enter which could be, again, ruled out in a sequential entry game or through the possibility of firm's coordination). The key feature of the direct model is that despite the winner takes all situation, the monopolist is direct and has an intrinsic incentive to improve the quality in order to increase its profit. In particular, the entrant (for example, firm 1) sets the following price and quality:

$$p_1^D = \theta_1 s^D - r \text{ and } s_1^D = \theta_1 n\gamma.$$

The entry is profitable if

$$(\theta_1 n)^2 \gamma - nr > K.$$

Notice that the winner takes all situation in the direct model is the artifact of the homogenous type 1 consumers assumption. In particular, if the vertically differentiated preferences are introduced within type 1 consumers, like in Shaked and Sutton (1983), then it is easy to get the natural oligopoly situation or the presence in the market of a line of products with different price quality ratios satisfying heterogenous preferences/incomes of consumers.

In contrast, the winner takes all situation in the indirect model is preserved when the heterogeneity in the type 1 consumers preferences is introduced, so the inability to relax competition through vertical differentiation is the robust feature of the indirect model. Moreover, in the indirect model the winner is the indirect monopolist suffering from the imperfection identified in the Proposition 1 of no intrinsic motivation to invest in quality improvements since all consumers are already captured while the price could not be raised from the zero level without significant losses in advertising revenues.

Proposition 2. *In a simple static quality competition model (simultaneous entry choice, simultaneous qualities choice, simultaneous prices choice) under the indirect model, in equilibrium only one firm enters and produces minimally acceptable quality s^{MA}. In the hypothetical subgame where* *both firms enter a significant (expected) quality improvement happens but the expected profits (gross of entry costs) are zero. In contrast, under the direct model in equilibrium a higher than the minimally acceptable quality* $s_1^D = \theta_1 n\gamma > s^{MA}$ *is created.*

The key idea of Proposition 2 is that in a situation when firms are choosing their quality once (for example when search engines commit to the long-term research programs), the competition between equally capable of quality improvement rivals could lead to the significant expected quality investments motivated by the desire to win all ad revenues in the market. Even though such a competition is ideal for consumers (since they get free and high-quality search engines in expectation), it is too far from ideal for firms who expect net losses since the firms could not cover the entry costs and hence firms prefer to avoid such a competition for quality in the first place.

1.7 Dynamic Competition for Quality

In this subsection, I relax the assumption of the static or one-shot quality competition while preserving the assumption that firms by investing some resources could always improve the quality of their search engines above the quality of the rival search engine. I ask how the dynamic nature of interaction could affect the entry in this market and incentives to improve the quality of the search engines.

As before, I assume that there are two symmetric in terms of innovation capabilities firms having the quality improvement cost function $c(s) = \frac{1}{2\gamma}s^2$ defined on $[0, +\infty]$. All firms are assumed to have a common discount factor $\delta \in (0, 1)$. The game consists of the infinite number of periods $t = 1, 2, ..$ At the initial period, $t = 1$, two potential entrants simultaneously decide whether to enter by investing $K > 0$, which represents the entry cost. The next each period ($t = 2, 3..$) consists of the following sequence of choices:

1. If only one firm entered at $t = 1$, then it chooses its quality level. If both firms entered at $t = 1$, then if the period is $t = 2, 2 + k, 2 + 2k, ..$, then firm 1, without loss of generality, chooses its

quality first and firm 2, observing the quality of firm 1, chooses its quality second[11,12]. k is the time required to innovate, or the necessary time for the investment in quality to result in the quality improvement. At any other periods, $t \neq 2, 2+k, 2+2k, ..$, firms do not make any quality improvement choices.

2. If both firms entered, then observing the qualities, they simultaneously set prices every period $t = 2, 3..$

3. Consumers choose which service to buy, and all payoffs are realized for the period t.

As will be seen shortly, there are two qualitatively different possibilities: either both firms enter, or only one firm enters. Which situation will occur depends on the per period discount factor δ and the time required to innovate k.

Consider the indirect model.

I maintain the Assumptions 4 and 5 in this section which state that type 2 consumers bring significant enough ad revenues that the superior quality search engine producer would setting zero price and attracting both groups of consumers.

Consider two possible types of equilibria depending on the per period discount factor δ and the time required to innovate k.

An indirect model equilibrium when $(\delta)^k \geq \frac{1}{2}$.

Suppose that the firms are using the following strategies:

[11]In the dynamic model, I use sequential quality choice by firms as opposed to simultaneous considered in the previous section only to make the model tractable. In the Appendix, I present a dynamic model where firms make simultaneous quality choices, and I get the qualitatively same result. The difference is that in that case when firms deviate from the collusive outcome, they randomize the level of quality improvement investments.

[12]In this basic version of the dynamic game I assume that there are no any side payments and in particular licensing is impossible. In the Appendix, I consider an extended version of the game where firm 1, after investing in quality and before firm 2 has invested in its quality, can make a take it or leave it offer to transfer the technology at the optimal for firm 1 price.

Both firms enter in the initial period $t = 1$. At the second period $t = 2$, both firms create minimal acceptable quality level, i.e., $s_{jt=2} = s^{MA}$ to attract all consumers at the zero price for the service. Then, firm 1, at the further investment periods $t = 2 + k, 2 + 2k, ..,$ chooses

$$s_{1t} = \begin{cases} s^{MA} & \text{if } s_{2t-k} = s^{MA} \\ \overline{s}^{\text{dyn}} & \text{if } s_{2t-k} \in \left(s^{MA}, \overline{s}^{\text{dyn}}\right) \\ s_{1t-k} & \text{if } s_{2t-k} \geq \overline{s}^{\text{dyn}} \end{cases} .$$

where $\overline{s}^{\text{dyn}}$, by analogy with the static model, represents the quality level such that the investments required to produce this quality completely exhaust all the present value of advertising revenues, i.e.,

$$\overline{s}^{\text{dyn}} = \left\{ s : \frac{\alpha N}{1-\delta} - \frac{1}{2\gamma} s^2 = 0 \right\}.$$

Firm 2, at the investment periods $t = 2 + k, 2 + 2k, ..,$ chooses

$$s_{2t} = \begin{cases} s^{MA} & \text{if } s_{1t} = s^{MA} \\ s_{1t} + \varepsilon & \text{if } s_{1t} \in (s^{MA}, s^{exit}) \\ \overline{s}^{\text{dyn}} & \text{if } s_{1t} \in [s^{exit}, \overline{s}^{\text{dyn}}) \\ s_{2t-k} & \text{if } s_{1t} \geq \overline{s}^{\text{dyn}} \end{cases} ,$$

where s^{exit} is the quality level for which the k-period gain of all advertising revenue is completely exhausted through the investments required to create s^{exit}, i.e.,

$$s^{exit} = \left\{ s : \alpha N \left(1 + \delta + .. + (\delta)^{k-1}\right) - \frac{1}{2\gamma} s^2 = 0 \right\}.$$

At all periods $t = 2, 3, ..$ both firms ($j = 1, 2$) set zero price for consumers

$$p_{jt} = 0.$$

The above-specified strategy profile constitutes a subgame perfect Nash equilibrium in which both firms produce the minimally acceptable quality s^{MA} and set zero prices for consumers if the following conditions hold (see the proof in the Appendix):

$$\begin{cases} \frac{1}{2}\frac{\alpha N}{1-\delta} \geq \alpha N \left(1+\delta+..(\delta)^{k-1}\right) \Leftrightarrow (\delta)^k \geq \frac{1}{2} \\ \frac{1}{2}\frac{\alpha N}{1-\delta} - K \geq 0 \end{cases}.$$

The first condition represents a condition under when there is no incentive to deviate from producing collusive minimally acceptable level of quality, s^{MA}. The second condition states that it is profitable to enter the market by both firms.

An indirect model equilibrium when $(\delta)^k < \frac{1}{2}$.

In this case, the unique subgame perfect Nash equilibrium is that only one firm (firm 1) enters at the initial period $t = 1$ and creates the minimally acceptable level of quality s^{MA} since it becomes the indirect monopolist. In this equilibrium Firm 2 never enters since it fears fully exhaustive competition for quality resulting in zero profits gross of entry costs and negative profits net of entry costs.

Notice that the reason why only one firm enters is the same as in the static model: firms predict too intense quality competition at the second stage when the entry costs could not be covered.

To summarize, the above-specified strategies constitute a subgame perfect Nash equilibrium (see the proof in the Appendix) if the following conditions hold:

$$\begin{cases} \frac{1}{2}\frac{\alpha N}{1-\delta} \geq \alpha N \left(1+\delta+..(\delta)^{k-1}\right) \Leftrightarrow (\delta)^k < \frac{1}{2} \\ \frac{1}{2}\frac{\alpha N}{1-\delta} - K \geq 0 \end{cases}.$$

The first equation states that if both firms enter, then each firm has a temptation to start competition for quality. The second condition states that if firms could collude by producing the minimally acceptable quality, then the entry would have been profitable by both firms.

Consider the direct model.

A direct model equilibrium when $\delta \geq \frac{1}{2}$

Suppose that $\delta \geq \frac{1}{2}$ and firms are using the following strategies.

At the initial period $t = 1$, both firms enter. At the second period $t = 2$ each firm chooses the following quality

$$s^{DcoopNL} = \frac{1}{2}\theta_1 n\gamma,$$

where $s^{DcoopNL}$ stands for cooperative quality under no licensing possibility.

Then, each firm chooses the following price

$$p_{it=2} = p^{DcoopNL} = \theta_1 s^{DcoopNL} - r = \frac{1}{2}(\theta_1)^2 n\gamma - r.$$

In later periods $t = 3, 4..$ firms maintain prices at the second-period price level $p_{it=2}$, and in the further investment periods, $t = 2 + k, 2 + 2k, ..,$ firms maintain their qualities at the second-period quality level $s^{DcoopNL}$, if no deviation happened in the past. If a deviation has occurred, then firms play a static Nash equilibrium (given the current quality levels) in this period and in all future periods, which means that firms set prices equal to marginal costs (zero) and do not invest in quality improvements anymore.

These strategies constitute a subgame perfect Nash equilibrium of the dynamic game (see the proof in the Appendix).

To summarize, the conditions under which both firms enter and produce quality $s^{DcoopNL}$, and set prices to $p^{DcoopNL}$, are

$$\begin{cases} \frac{1}{2}\frac{\pi^{DNL}}{1-\delta} \geq \pi^{DNL} \Leftrightarrow \delta \geq \frac{1}{2} \\ \frac{1}{2}\frac{\pi^{D}}{1-\delta} - \frac{1}{2\gamma}\left(s^{Dcoop}\right)^2 - K \geq 0 \end{cases},$$

where: $\pi^{DNL} = \frac{n}{2}\left(\theta_1 s^{DcoopNL} - r\right)$ is the one period profit flow (gross of entry and quality investment costs). The first condition states that if both firms enter, then it is profitable for both to cooperate on qualities and prices. The second condition states that expecting cooperation on price both firms enter find it profitable to enter.

A direct model equilibrium when $\delta < \frac{1}{2}$

Suppose that $\delta < \frac{1}{2}$ and firms are using the following strategies. Firm 1 enters at $t = 1$ and creates at the $t = 2$ the following quality and sets in all periods $t > 1$ the following prices

$$s^D = \theta_1 n\gamma \text{ and } p^D = \theta_1 s - r = (\theta_1)^2 n\gamma - r.$$

Firm 2 does not enter.

Such a strategy profile is the unique subgame perfect Nash equilibrium[13] of the dynamic game since the entry of both firms leads to the full profit dissipation that does not allow covering the entry investments.

To summarize, the conditions for only one firm entry in the direct model are:

$$\begin{cases} \frac{1}{2}\frac{\pi^D}{1-\delta} < \pi^D \Leftrightarrow \delta < \frac{1}{2} \\ \frac{\pi^{DNL}}{1-\delta} - \frac{1}{2\gamma}\left(s^{DcoopNL}\right)^2 - K \geq 0 \end{cases}.$$

The first condition states if firms enter and invest to create the quality $s^{DcoopNL}$, then each firm will have an incentive to undercut the price of the rival resulting in the static Nash equilibrium (given the quality $s^{DcoopNL}$) when both firms set prices equal to the marginal costs (which are normalized to zero). The second condition states that if firms were able to cooperate on prices and qualities, then it would have been profitable to enter by both firms.

This section's main conclusions are summarized in the following proposition.

Proposition 3. *In an infinite horizon dynamic quality competition model with indirect financing where prices are set every period and investments in quality are made every k periods if* $\delta^k \geq \frac{1}{2}$, *then there exists a subgame perfect Nash equilibrium where both firms enter and collude on producing the minimally acceptable level of quality* s^{MA}. *Such an equilibrium is Pareto superior from the*

[13] Since I assume that firm 1 has a first-mover advantage at the quality investment stages, then there is a unique equilibrium of the whole game in this case. If firms moved simultaneously at all stages, then there would be a standard situation that there are two pure strategy equilibria when either firm 1 or firm 2 enters and a mixed strategy equilibrium when each firm enters with some probability. As before, mixed strategy equilibria could be ruled out either through the sequential entry or through the coordinated entry.

firms' perspective to any other equilibrium. If $\delta^k < \frac{1}{2}$, then only one firm enters and creates minimally acceptable quality s^{MA}. In contrast, in the direct model without licensing, if $\delta \geq \frac{1}{2}$, both firms enter and each produces the cooperative quality $s^{DcoopNL} = \frac{1}{2}\theta_1 n\gamma > s^{MA}$, while if there is cost sharing, then firms jointly produce the cooperative quality $s^{DcoopL} = \theta_1 n\gamma > s^{MA}$. Such an equilibrium is Pareto superior from the firms perspective to any other equilibrium. If $\delta < \frac{1}{2}$, then only one firm enters and produces $s^D = \theta_1 n\gamma > s^{MA}$.

The main lesson of Proposition 3 is that the lack of cooperative incentive to improve the quality identified in Proposition 1 could be realized in practice in a dynamic setting under certain conditions. Dynamic model allows identifying conditions under which collusion on lower quality is more probable to occur. Besides per period discount factor, a crucial factor is the time required to make innovation, that is measured by k (Alternatively, k could be interpreted as the degree of commitment to the research plan). If the time required to innovate is quite long, then it is impossible to sustain collusion on quality, and the dynamic model is equivalent to the static model studied in the previous section. On the other hand, if the time required to innovate is short, then firms could easily relax quality competition through collusion on lower quality allowing both firms to enter. The distinction between these two situations could be important from the policy perspective. In particular, if the time required to innovate is quite long, then one possible policy could be to subsidize the entry cost K such that both firms entry would result in a significant quality improving competition. On the other hand, such a policy of subsidizing entry costs may be unproductive when the time required to innovate is short since additional firms would end up colluding on quality.

Notice that, in contrast to the indirect model, in the direct model cooperation on prices and qualities does not depend on the time required to innovate and depends only on the degree of patience per period measured by δ. Hence, the direct model predicts a higher probability of several firms entry since prices could be adjusted quicker that quality investments. Moreover, cooperation on prices creates significant incentives to invest in quality improvement since such an improvement increases permanently the profit flows in the industry. Even if firms are not sufficiently patient to cooperate on prices and qualities, then only one firm enters the market, and such a firm becomes the direct monopolist producing higher-quality search engines.

1.8 Discussion

1.8.1 Welfare Analysis

Search engine market welfare analysis

In this section, I will revisit the Section 5 analysis of the innovator monopolist search engine incentives for quality improvements from the normative perspective. I will derive total and consumer welfare comparisons between the indirect model and the direct model. Since there is a positive outside option value of r for all consumers, I will calculate the welfare without deducting the value of the outside option value r, i.e., I will make welfare calculation gross of outside value r.

Under Assumption 1 and Assumption 2 the *total welfare* in the market for the search engine consumers under the indirect model with a monopolist innovator firm is

$$TW_{SE}^{ID} = n\theta_1 s^{MA} + (N - n)\,\theta_2 s^{MA} - \frac{1}{2\gamma}\left(s^{MA}\right)^2 .$$

Since, by assumption, $\theta_2 s^{MA} = r$, I get

$$TW_{SE}^{ID} = n\theta_1 s^{MA} + (N - n)\,r - \frac{1}{2\gamma}\left(s^{MA}\right)^2 .$$

Since the price for consumers in the search engine market is zero under Assumption 2, the *consumer welfare* in the market for the search engine for consumers is

$$CW_{SE}^{ID} = n\theta_1 s^{MA} + (N - n)\,\theta_2 s^{MA}.$$

Since, by assumption, $\theta_2 s^{MA} = r$, then and I get

$$CW_{SE}^{ID} = n\theta_1 s^{MA} + (N - n)\,r.$$

Notice that the consumer welfare for type 2 consumers is the same as the outside option value, r, while the consumer welfare for type 1 consumers is $\theta_1 s^{MA} > r$. The latter improvement for the type 1 consumers is due to the simplifying assumption that r is common to both types, $r = \theta_2 s^{MA}$. If the outside option value would be type specific in the following natural way, $r_i = \theta_i s^{MA}$ for $i = 1, 2$, then the consumer welfare under the indirect model would be identical to the outside option value which is anyway available to consumers.

Consider the direct model.

Analogous calculations give the following *total welfare* for the direct model

$$TW_{SE}^{D} = n\theta_1 s^D + (N - n) r - \frac{1}{2\gamma} \left(s^D\right)^2 .$$

Substituting $s^D = \theta_1 n\gamma$ results in

$$TW_{SE}^{D} = \frac{(\theta_1 n)^2 \gamma}{2} + (N - n) r.$$

Since the price is $p^D = \theta_1 s^D - r = (\theta_1)^2 n\gamma - r$, the *consumer welfare* under the direct model is

$$CW_{SE}^{D} = Nr.$$

Summarizing the above calculations it is seen that the total welfare of the direct model is greater than the total welfare of the indirect model if

$$n\theta_1 s^D - \frac{1}{2\gamma} \left(s^D\right)^2 > n\theta_1 s^{MA} - \frac{1}{2\gamma} \left(s^{MA}\right)^2$$

This condition is always satisfied if $s^D \neq s^{MA}$ since the left-hand side of the equation is equal to the direct monopolist's profit function, and the direct monopolist chooses to create the quality s^D since it maximizes its profit and hence the left-hand side of the above inequality. On the other hand, the consumer welfare is higher in the indirect model due to the simplifying assumption that the outside option value is common to both types of consumers and equals to $r = \theta_2 s^{MA}$. If the outside values were naturally defined as $r_i = \theta_i s^{MA}$ for $i = 1, 2$, then the consumer welfare in both models would have been the same.

Also, notice that the fact that consumer welfare equals the outside option value, Nr, in the direct model is the result of the simplifying assumption that type 1 consumers are all the same, which allows the monopolist to extract all consumer value above the outside option value. The introduction of the type 1 consumer heterogeneity could make the consumer surplus higher under the direct model than under the indirect model but it will also introduce some standard deadweight loss associated with underproduction of the service when the price is above the marginal costs.

Welfare analysis of the whole economy

As I mentioned before search engines play an essential role as the infrastructure of the New or Information economy affecting both online and offline world. Hence a proper welfare analysis of the search engines quality should take into account the externalities (either good or bad) on all other markets and activities which use search engines as the inputs. The simplest possible extension of the baseline model that could capture such a feedback effect is the following.

Let q is composite Hicksian good that represents all markets and activities in the economy except the search engine market. I normalize the price of the composite Hicksian good to 1. Search engine market is represented by the search engine service quantity consumed, q_{SE}, and each consumer has a unit demand for search engines, i.e. $q_{SE} \in \{0, 1\}$. Let $y_i(s)$ represents the income of consumer $i = 1, 2$ generated in other markets than the search engine market per se. A consumer of type $i = 1, 2$ has quasi-linear preferences and hence maximizes the following quasi-linear utility function

$$\max_{q_i^{SE} \in \{0,1\}, q_i \geq 0} \left\{ \max \left\{ \theta_i s q_i^{SE}, r \right\} + q_i \right\},$$

subject to the budget constraint

$$p q_i^{SE} + q_i = y_i \{s\},$$

where $y_i(s)$ is the type $i = 1, 2$ consumer income and r is, as before, the value of the outside option if consumers decide not to use any search engines and which is common to all consumers (for simplicity).

I assume that the consumer $i = 1, 2$'s income is increasing in the quality of the search engine,

$$y_i' \{s\} > 0.$$

Substituting the budget constraint into the utility function gives

$$\max_{q_i^{SE} \in \{0,1\}, q_i \geq 0} \left\{ \max \left\{ \theta_i s q_i^{SE}, r \right\} - p q_i^{SE} + y_i \{s\} \right\}.$$

This simple model demonstrates that the quality of the search engine affects consumer utility not only in the search engine market per se, but also through a positive (or negative) externality that better (or worse) search engines create for the economy as a whole. *The information overload concept* captures both effects of higher quality on the search engine market per se as well the effect that search engine quality generates for the rest of the economy. Next, I will calculate the total and consumer welfare of the search engine quality for the whole economy.

Consider the indirect model.

The *total welfare* for the whole economy under the indirect model of search engines is

$$TW_{Economy}^{ID} = \left[n\theta_1 s^{MA} + (N-n) r - \frac{1}{2\gamma} \left(s^{MA} \right)^2 \right] + \left[n y_1 \left\{ s^{MA} \right\} + (N-n) y_2 \left\{ s^{MA} \right\} \right].$$

The *consumer welfare* for the whole economy under the indirect model of search engines is

$$CW_{Economy}^{ID} = \left[n\theta_1 s^{MA} + (N-n) r \right] + \left[n y_1 \left\{ s^{MA} \right\} + (N-n) y_2 \left\{ s^{MA} \right\} \right].$$

Consider the direct model.

The *total welfare* for the whole economy under the direct model of search engines is

$$TW_{Economy}^{D} = \left[\frac{(\theta_1 n)^2 \gamma}{2} + (N-n) r \right] + \left[n y_1 \{\theta_1 n \gamma\} + (N-n) y_2 \{\theta_1 n \gamma\} \right].$$

The *consumer welfare* for the whole economy under the direct model of search engines is

$$CW_{Economy}^{D} = \left\{ (\theta_1 n)^2 \gamma + (N-n) r \right\} + \left[n y_1 \{\theta_1 n \gamma\} + (N-n) y_2 \{\theta_1 n \gamma\} \right].$$

Hence, I can calculate the total welfare difference for the indirect model as compared to the direct model in the following way

$$TW^{ID}_{Economy} - TW^{D}_{Economy} = \left[\left[n\theta_1 s^{MA} - \frac{1}{2\gamma}\left(s^{MA}\right)^2\right] - \left[n\theta_1 s^{D} - \frac{1}{2\gamma}\left(s^{D}\right)^2\right]\right] + \\ + \left[n\left(y_1\left\{s^{MA}\right\} - y_1\left\{\theta_1 n\gamma\right\}\right) + (N-n)\left(y_2\left\{s^{MA}\right\} - y_2\left\{\theta_1 n\gamma\right\}\right)\right].$$

The first term in squared brackets is negative for $s^D \neq s^{MA}$ (since s^D maximizes the expression $n\theta_1 s - \frac{1}{2\gamma}(s)^2$) and it measures the loss from using the indirect model in the search engine market per se. If $s^D > s^{MA}$, then the second term is negative and it measures the loss resulting from the indirect model for the rest of the economy's markets and activities. Hence there is an additional total welfare loss for the economy as a whole from using the indirect model.

Hence, the welfare analysis of the indirect versus direct model of the search engine market could be summarized as follows.

Proposition 4. *Under the assumptions of Section 5 (innovator monopolist), the total welfare under the indirectly financed search engine market considered in isolation from the other markets is lower than the total welfare under the direct model. In a model with homogenous type 1 consumers, consumer welfare is higher under the indirect model if the outside option values are the same and equal to* $r_1 = r_2 = \theta_2 s^{MA}$*. If the outside options values are different and equal to* $r_1 = \theta_1 s^{MA}; r_2 = \theta_2 s^{MA}$*, then the consumer welfare equals to the value of the outside option,* Nr*, in both direct and indirect models but the total welfare is higher under the direct model. Taking into account the effect of the search engine quality on other markets and activities results in an additional welfare loss (both total and consumer) under the indirect model as compared to the direct model.*

1.8.2 Explanation for the One Product Assumption

One crucial possible explanation why the innovator monopolist may decide not to introduce the paid higher quality version in addition to the basic version (of a minimally acceptable quality) under the indirect model is that there is an inferior alternative search engine producer in the market which is not able to innovate but can absorb the spillovers from the innovator's quality. As a result, the creation by the innovator monopolist of a premium higher quality service would allow the inferior alternative search engine to improve its quality even higher than the quality of the innovator's basic service if the innovator would not adjust the quality of the basic service accordingly. However, such an adjustment (which will be an increase) in the basic service quality provided for free for consumers would reduce the profits of the premium quality sector and could make it not profitable to create such a premium service in the first place.

In contrast, under the direct model, the entry into the inferior alternative sector may not be a profitable project. The reason is that in the direct model there are no ad revenues and the only source of income comes from charging consumers directly. However, some consumers, who were happy to participate in the search engine market when the price of the search engines was zero, may not participate in the market when the price is positive. As a result, in the direct model the market size shrinks and in case if firms do not cooperate on prices, then only one firm could profitably enter. If firms could cooperate on prices, then several firms may enter. However, notice, in both cases spillovers do not reduce the incentive to improve the quality. In the static model case, only one firm enters and, hence, there is no inferior alternative that would absorb the spillover. In the dynamic model, any spillovers are fully internalized though cooperative price setting. Moreover, if there is vertical differentiation for type 1 consumers, then a natural oligopoly could easily be the outcome when several firms enter and create a line of search engines with different price-quality options.

Let me demonstrate this idea for the static model by extending the baseline model a little bit. Since the inferior alternative firm is not able to create the quality above the level of the innovator monopolist firm, then the only possibility for the inferior alternative firm to get some profit is through horizontal differentiation. Hence, I will assume for simplicity[14] that some type 2 consumers value an additional feature h that is not present in the innovator firm's service and which is present in the inferior alternative firm's service. I will refer to such consumers as *type 2*

[14] I assume that all type 1 consumers do not value such an additional feature, which could easily be relaxed without loss of generality.

loyal consumers and there are $\delta(N-n)$ of them. The willingness to pay of type 2 loyal consumers for such an additional feature is $\tau \equiv \theta_2 h$. Other consumers do not value the additional feature h at all. Hence, the consumer surplus of type 2 loyal consumers from using the inferior alternative alternative search engine with a feature h is $CS_{2,\delta}(IA) = \theta_2(s_{IA}+h) - p_{IA}$, where p_{IA}, s_{IA} are the price and quality set by the inferior alternative search engine. Other consumers (type 2 non-loyal consumers and type 1 consumers) have the same consumer surplus as in the baseline model. I will make the following assumption.

Assumption 6. $\beta s^{MA} + h > s^{MA}$

Assumption 6 states that type 2 loyal consumers think that the overall quality is higher than the minimally acceptable quality created by the innovator monopolist firm.

I will consider an entry game between the innovator monopolist search engine and an inferior alternative search engine. The entry for the innovator monopolist costs K, while the entry cost for the inferior alternative firm is K_{IA}. The entry choice happens simultaneously. If both firms enter, then the innovator firm chooses the quality level s, while the inferior alternative firm automatically absorbs the spillovers from the innovator firm and creates the quality $s_{IA} \equiv \beta s$. For simplicity, I will assume that "absorbing" the spillovers is free for the inferior alternative firm, while creating the quality by the innovator costs $c(s) = \frac{1}{2\gamma}s^2$. Finally, at the third stage, firms set the prices.

Consider the indirect model. Under Assumptions 1 (stating that the innovator monopolist would prefer to set its price and quality such that both types of consumers are attracted) and Assumption 2 (stating that the innovator monopolist creates minimally acceptable quality at the zero price for consumers) hold and if both firms enter, then at the third stage, the price set by both firms is zero, and the (vertical) quality is at the minimally acceptable level

$$p^{ID} = 0,\ p^{ID}_{IA} = 0,\ s^{ID} = s^{MA},\ \text{and}\ s^{ID}_{IA} = \beta s^{MA},$$

where p_{IA}, s_{IA} denote the price and quality set by the innovator monopolist, while p^{ID}_{IA}, s^{ID}_{IA} are the price and quality set by the inferior alternative firm. Notice, that type 1 and type 2 consumers would never use inferior alternative search engine since in their view its quality is below the outside option quality of s^{MA}. In contrast, under Assumption 6, type 2 loyal consumers value the additional feature h enough to prefer the inferior alternative search engine to the innovator monopolist's search engine of the minimally acceptable quality s^{MA}.

Hence, in equilibrium, both firms enter if

$$\begin{cases} \Pi^{ID} = \alpha\left(n + (1-\delta)(N-n)\right) - K - \frac{1}{2\gamma}\left(s^{MA}\right)^2 > 0 \\ \Pi^{ID}_{IA} = \alpha\delta(N-n) - K_{IA} > 0 \end{cases}.$$

Consider now a situation when the monopolist innovator decides to introduce a higher quality premium search engine with quality s_P and price p_P, in addition to the basic service with quality s and price p. I am assuming that the introduction of the premium service with the higher quality, $s_P > s$, is profitable for the innovator monopolist, and then I will present the conditions on parameter values when this assumption is correct and when not.

In order for the innovator monopolist not to lose the basic free service market to the inferior alternative firm (with the quality $s_{IA} = \beta s_P$), the following constraint should be satisfied for the basic service

$$s \geq s_{IA} = \beta s_P \text{ and } s \geq s^{MA}.$$

The problem of the innovator monopolist is

$$\Pi^{ID}_P = \max_{s_P, s}\left\{n\theta_1\left(s_P - s\right) + \alpha\left(n + (1-\delta)(N-n)\right) - K - \frac{1}{2\gamma}\left(s_P\right)^2\right\}.$$

It is seen that the above constraint should hold with an equality ($s = s_{IA} = \beta s_P$) in order to maximize the profit in the premium sector. Hence, the profit function of the innovator monopolist could be rewritten as

$$\Pi_P = \max_{s_P}\left\{n\theta_1(1-\beta)s_P + \alpha\left(n + (1-\delta)(N-n)\right) - K - \frac{1}{2\gamma}\left(s_P\right)^2\right\}.$$

The optimal qualities are

$$s_P = \begin{cases} \theta_1 n(1-\beta)\gamma, \text{ if } \theta_1 n(1-\beta)\gamma > s^{MA} \\ s^{MA}, \text{ if } \theta_1 n(1-\beta)\gamma < s^{MA} \end{cases} \text{ and } s = s^{MA}.$$

Hence, it is seen that the quality of the premium service negatively depends on the degree of the partial spillover β. For a relatively high spillover β and especially if it is too costly (γ is low) to create the premium service, it may be optimal not to create the premium service at all and just to enter with the minimally acceptable quality level s^{MA} to attract most of the consumers with a free basic service.

Assumption 7. $\theta_1 n (1-\beta) \gamma < s^{MA}$.

Assumption 6 states that if the degree of spillovers is high enough, then it is not profitable to create a separate premium paid service, so it is profitable to create just one free service with the minimally acceptable quality.

Consider the direct model. Under Assumption 5 (stating that type 2 consumers are not willing to pay for the search engines at all, i.e. $\theta_2 = 0$) if both firms enter, then they will charge the following prices:

$$p^D = \theta_1 (1-\beta) s, \text{ and } p^D_{IA} = 0.$$

As a result, firms get the profits

$$\Pi^D = \theta_1 (1-\beta) s - \frac{1}{2\gamma} s^2 - K, \text{ and } \Pi^D_{IA} = -K_{IA}.$$

Therefore, it is seen that it is never profitable to enter by the inferior alternative firm in the direct model market and only the innovator monopolist enters and sets the price and quality

$$p^D = \theta_1 s^D \text{ and } s^D = \theta_1 n \gamma$$

and gets the profit

$$\Pi^D = \frac{(\theta_1 n)^2 \gamma}{2} - K.$$

This subsection is summarized in the following proposition.

Proposition 5. *Under Assumptions 5, 6, and 7 in the indirect model with quality spillovers, both an innovator monopolist and an inferior alternative firm enter the market; indirect monopolist avoids creating a premium paid service and provides only a free basic service of the minimally acceptable* *quality s^{MA}. In contrast, under the direct model, only the innovator monopolist enters*[15] *and creates much higher than the minimally acceptable quality, $s^D = \theta_1 n\gamma > s^{MA}$.*

1.9 Summary and Conclusions

The development of the Internet and other information technologies lead to significant information accumulation. That has created a natural demand for higher quality search engines. In this paper, I suggest the currently ubiquitously used advertising based (or indirect) model to finance search engines could pose an important obstacle in the search engines incentives to supply the quality of the search engines fully satisfying the demand by many consumers and society as whole. To establish this result, I compare indirect with the direct model of search engine financing. I find that the indirect monopolist has a relatively low incentive to improve the quality. The intuition is that once all consumers are attracted, further quality improvements could not be monetized. For example, suppose the indirect monopolist increases the quality above the minimum acceptable level and decides to charge higher (positive) price to consumers. In this case, a significant part of consumers whose willingness to pay is low will prefer not to participate in the market by choosing the outside option (such as using inferior free search engines or traditional sources of information such as TV, radio etc). Hence, the increase in the direct revenue may not be able to compensate the decrease in the indirect revenue under realistic parameter values. Hence, it can be concluded that the indirect model of search engine financing creates an obstacle to quality improvement incentives if the search engine becomes a monopolist in innovation activities.

After showing that a combination of the monopoly in innovation activities and indirect model of search engine financing leads to insufficient incentives to improve the search engines quality, I turn to the question will competition lead to higher quality, and more importantly, will competition happen in this market in the first place? In order to answer these questions, I considered a three-

[15] Again, the fact that only one innovator enters is due to the simplification that type 1 consumers are homogeneous. In practice, due to vertical differentiation of type 1 consumers like in Shaked and Sutton (1983), several innovator firms may enter providing search engines with different quality-price characteristics satisfying different groups of type 1 consumers.

stage model where at the first stage firms simultaneously choose whether to enter the market, at the second stage simultaneously choose the level of quality and at the final stage choose prices. I find that in the indirect model if both firms enter, then a significant quality competition happens. But, in such a subgame the expected profits are completely dissipated, which means that in a pure strategy equilibrium only of the firm would enter this market and, hence, the actual quality competition would never happen in practice.

Despite the interesting insight obtained in the static model, it neglects potentially important dynamic aspects of quality competition. Moreover, an important measure of competition as the number of active firms in the market could have a very different interpretation when dynamic aspects are introduced. In particular the one-shot or static model would characterize well quality competition where the nature of technology is such that firms need to commit to long-term research directions when the choice is made once and it affects profitability over relatively long period of time. Hence, I consider a dynamic competition framework that generalizes the static model for the case when the time required for innovation is relatively long. In contrast, if the time for innovation is relatively short, several firms may enter and successfully collude by producing minimally acceptable quality. The parameter measuring the time required to innovate is an important policy indicator. If it could be identified that the search engine market is characterized more by long-term quality competition with a significant time required to innovate, then an important policy tool could be the subsidization of the entry costs for the innovative rivals. In contrast, such a subsidization may be useless if the nature of quality competition is dynamic and, hence, allows entering firms to collude on quality with the incumbent. In contrast, the direct model predicts significant incentive to improve the quality independent of the time required for innovation and the number of entered firms since quality improvements permanently increase the industry profit flows.

In the section devoted to welfare analysis I point out that the proper welfare analysis of the search engine market should not only consider the search engine market per se, but also to take into account the positive (or negative) externality that a higher (or lower) quality search engines create for all the markets in the economy. It is this externality underlies the motivational idea of the information overload in this market. I find that the direct model predicts higher total welfare both for the search engine market per se as well as the economy as a whole. Consumer welfare comparison of the direct and indirect model depends on the assumptions regarding the value of the outside option, the degree of consumer heterogeneity as well as the strength of the externality of the higher quality search engines to other markets. In particular, if the strength of the latter externality is high enough, then the consumer welfare could be higher under the direct model than under the indirect model.

Finally, since the key result of the paper depends on the assumption of the one service search engine I give an explanation for this assumption. Moreover, the proposed explanation is justified by the anecdotal evidence and stylized facts in this market. In particular, I suggest that the introduction of the quality spillovers (or "search results scraping") to the inferior alternative rival gives a compelling explanation for the one product phenomenon. I find that under the indirect model in the presence of the significant but partial spillovers it is profitable for the inferior alternative firm to enter with the hope to attract some loyal consumers through a minor horizontal differentiation and spillovers absorption. Such an entry significantly reduces the profitability of introducing a premium paid service in addition to the basic free service since the premium higher quality service reveals higher quality search results to the rivals who could use it in the main basic market to steal significant advertising revenues. In contrast under the direct model, spillovers do not play such a role since either the inferior alternative firm does not have enough differentiation to enter the market profitably or since the entering firms could cooperate on prices internalizing spillovers

In my view, the current search engine market is characterized as either quality innovation monopoly situation or collusion in quality innovation activities that prevents the quality improvements in the interests of society. Hence, the incentives to create premium paid search engines should be improved in the interest of society. If the reality is characterized by the monopoly in innovation activities situation, then in the indirect model a quality spillover from the premium to the basic segment reduces the incentive for the R&D capable firm to invest in the premium segment. In this case, under the indirect model improving intellectual property protection which would reduce the quality spillovers (or scraping), would incentivize the creation of the premium paid services segment. On the other hand, if the reality is characterized by the presence of several capable to innovate firms (potential or actual) and the reason that they do not invest much in quality improvement is that either there is a winner takes all situation in a static framework or collusion in quality in the dynamic framework, then another approach may help. One way to avoid the winner takes all situation is to introduce the price floor in the premium segment. Such a price floor will guarantee that the entrant in the premium segment will not have the ability (even though it will have an incentive) to steal the ad business of the incumbent by lowering the price of its higher quality service to zero which would induce significant retaliatory quality improvements by the incumbent, the expectation of which would deter entry. In the cooperation/collusion context, a premium service price floor would help (especially in the absence of side payments) since the premium segment firm may have much lower profits (at least initially) due to the significant costs of quality improvement and hence there are significant incentives to deviate by lowering its price and attracting the basic segment consumers. Price floor would allow establishing a premium segment where firms may cooperate on price and investments (including licensing of innovations) to improve the premium segment quality to the demanded by the society level.

Another possible policy is to consider under the indirect model is subsidization of entry that would promote the static competition. Since the static competition represents commitments to long-term research directions, the funding of fundamental research related to search engines algorithms may induce quality competition in this sector despite its dissipative nature. The main risk to this policy strategy is related to the dynamic interactions that maybe inherent to the quality improvement technology in this market and that may induce quality collusion wasting any government subsidies to promote entry in this market.

In my view, the best way this market to be organized is to make search engines using the direct model. It does not mean that the advertising should be banned. It means, though, that the search engine function and advertising functions should be served by the independent entities. In this case, the consumer will pay directly to the search engine producer for the service and may choose whether to participate in the advertising platform by sharing its search history and providing attention. In case a person agrees to participate, then she receives the price for purchasing her information and her attention while using the search engine. An alternative scenario would be replicating the iPhone and Android industry conditions where the owner of iPhone, Apple, does not have access to significant advertising revenues as the owner of the Android, Google, and, hence, Apple has to use the direct model creating significant innovation incentives, while Google, having access to significant advertising revenues, makes its product much cheaper or more accessible.

CHAPTER 2

STRATEGIC CONTROL AND EXCLUSIVITY

2.1 Introduction

What if competing two-sided platforms do not take as given the regime of control over content pricing (outright sale or affiliation), but strategically choose over content control? What is the motivation for a strategic choice of the control regime for platforms and content providers? Will platforms and content providers be able to maximize their joint industry profit under different conditions? Do equilibria exist in this case, and what kind of equilibria will we observe in the market? Will we observe exclusive equilibria or not? Will we observe outright sale or affiliation types of content control? What will determine certain types of equilibria? Who will benefit and lose from strategic interaction over control? Those are the motivating questions.

The focus of the paper is on software industries such as video games and media broadcasting which are characterized by severe competition between two-sided platforms. In those industries, an important weapon in competition is the ability to attract content exclusively as well as, potentially, to set the regime of control over content. The reason is that one of the main ways to vertically differentiate for platforms is to have exclusive content. On the other hand, the allocation of control rights over content between a platform and content providers determines the net consumer surplus from content that, again, determines the degree of attractiveness of the platform for consumers.

This paper extends Hagiu and Lee (2011) by asking what if the regime of control, outright sale or affiliation, is strategically chosen as opposed to exogenously given.

As a first pass, the paper considers a model with homogeneous preferences over content which corresponds to the Example 3 in Hagiu and Lee (2011) as well as several simplifying assumptions discussed in the section describing the extended model. This simple specification facilitates extension while at the same time gives the baseline answer to the posed questions. It also could serve as a benchmark for further generalizations of the framework for arbitrary content preferences.

The main results of Hagiu and Lee (2011) are replicated, and it is demonstrated that the industry profit is higher under affiliation multihoming regime. Then, equilibria of Hagiu and Lee (2011) are derived in their framework: under outright sale regime there is a unique exclusive equilibrium for any level of content valuation; under affiliation regime, for any level of content valuation there are multiple equilibria (unique exclusive and multiple multihoming), and if platforms could coordinate (selection criterion applies), then all content provider's profits from content are extracted. This establishes the conflict of interests concerning control regime between platforms and content providers which motivates Hagiu and Lee's (2011) conjecture for the possibility of strategic choice over control to achieve the maximum industry profit. The goal of this paper is to formalize this idea and to explore its implications.

The key findings of the paper are the following.

First, for low and medium values of content (that does not induce consumer tipping for exclusive outright sale) platforms will never choose outright sale regime of control in equilibrium in contrast to the model with exogenous control regimes[1]. The explanation is that platforms will always have an incentive to deviate from the outright sale exclusive option to the affiliation exclusive option since it allows platforms to soften their competition for content and to transfer less of their surplus to content providers. Plus, such a deviation creates enough resources to be profitable for both the deviating platform and content providers. Moreover, in this case, there are multiple affiliation equilibria (multiple exclusive and multiple multihoming), and multihoming gives higher industry profit than exclusivity. If platforms could coordinate (selection criterion applies), then affiliation multihoming equilibrium which maximizes industry profit is the outcome such that platforms extract all content providers profits.

Second, for the case of high valuation content (that could potentially lead to the consumer tipping in favor of one of the platforms if signed exclusively with one of the platforms under outright sale

[1]Notice, Hagiu and Lee (2011) in their Corollary 3 show that (but for the case of strategic content provider) that second stage profits of both platforms are higher under exclusive affiliation than in exclusive outright sale which could motivate platforms to avoid vertical integration into content and spin off content into affiliation regime. In this paper, it is shown that it is actually an equilibrium outcome.

regime) the following results are obtained. There are two types of equilibria: exclusive outright sale and multihoming affiliation. However, multihoming affiliation creates higher industry profit, and if platforms could coordinate (again, if the selection criterion applies), then they could always choose a multihoming content allocation. An interesting implication of endogenous control regime choice is that now content providers with the high valuation, even in the case when platforms could coordinate on equilibria that are best for platforms and worst for content providers, get a significant share of industry profit. Moreover, this share increases as content valuation increases. The main reason is that if platforms extract too much profit from content providers in multihoming affiliation, then each platform has an incentive to propose an exclusive outright sale contract that content providers will accept since content providers have too low profit in multihoming affiliation. This result is very different as compared to exogenous control regime model where the inability to choose control regime plays the role of a commitment device allowing platforms (when coordinated) to extract all content profits independent of how high is the content valuation.

Third, if platforms could not coordinate (and, thus, selection criterion does not apply), then there are additional (as compared to the basic model with exogenous control regimes) equilibria due to possible pessimistic expectations of platforms regarding the behavior of content providers. In particular, any platform would always prefer (whenever it does not participate in the bidding for content) content provider to switch to exclusive affiliation option from the rival, rather than exclusive outright sale option. The reason is that outright sale option creates higher vertical differentiation between the platforms and, thus, makes platform competition for content more severe and results in higher platforms profits transfer to content providers. Thus, in those pessimistic platforms' expectations equilibria content providers can extract additional (as compared to the basic model) profits from platforms. Those additional affiliation equilibria appear for any level of content valuation and, thus, there are equilibria where content providers extract not only all content profit but also profits from selling platforms. Nevertheless, ability by platforms to coordinate (selection criterion applies) allows them to avoid such pessimistic platforms expectations.

These findings are summarized in Figure B.1. It allows a comparison of the basic model of

Hagiu and Lee (2011) with exogenous content control sets of equilibria and those of the extended model with endogenous control over content.

Currently, most literature on two-sided markets is related to the analysis of platform pricing decisions in order to get all sides on board. The benchmark articles that have formalized two-sided markets models are Rochet-Tirole (2003, 2006) and Armstrong (2006). The key aspect of two-sided markets is the presence of indirect network effects between the sides that platforms should take into account when they choose prices such that to bring all sides on board. On the other hand, those articles do not consider the possibility of exclusive contracts and, thus, implicitly assume that there is a commitment by the competing platforms for setting price only non-exclusively.

Choi (2010) considers exclusive content in two-sided markets, but exclusivity is exogenous; it is exclusive because it is technologically impossible or too costly to encode such content on the other platform and not because of an exclusive contract. In this case, each platform has exclusive content that makes natural for some consumers to multihome in order to get access to all exclusive content.

The role of exclusive contracts in two-sided markets was analyzed (to the author's knowledge) in two articles. First, Armstrong and Wright (2007) extend a basic model of Armstrong (2006) to allow platforms to propose exclusive contracts and finds that such exclusive contracts could undermine competitive bottleneck equilibria (where sellers multihome and buyers singlehome), and such exclusivity is beneficial for sellers and adverse for buyers. The second article, Hagiu and Lee (2011), and which is extended in this paper, entirely focuses on exclusive contracts (and control) in two-sided markets and addresses the question of how control regime over content (that is given exogenously) affects exclusivity. Two articles use quite different modeling strategies, where Armstrong and Wright (2007) considers more general formulation while Hagiu and Lee (2011) fine-tune the model to reflect software platform industries features. Despite this, a similar result to Armstrong and Wright (2007) is found in Hagiu and Lee (2011) where multihoming (or competitive bottleneck) equilibrium is undermined but only for outright sale regime. In contrast, the affiliation regime is characterized by multiple equilibria (unique exclusive and multiple multihoming) and given platforms could coordinate multihoming regime is always chosen as it brings higher industry profit.

The research on control regimes of content in multi-sided platforms is emerging. Hagiu (2007) analyzes the distinction between "merchant" mode (buying from seller and reselling to buyer or "outright sale regime" in this paper) and "two-sided platform mode" (enabling affiliated sellers to sell directly to affiliated buyers or "affiliation regime" in this paper) but in a monopoly framework and takes those regimes as exogenously given to compare advantages and disadvantages of both regimes under different scenarios (whether chicken-and-egg problem is severe or not, whether degree of complementarity between seller's products is high or not, whether there are incentives to invest in seller's product quality and whether there is asymmetric information regarding the seller's product quality). Hence, while Hagiu (2007) does not deal with platform competition issues, it gives additional motivations for the role of control regimes and, thus, as Hagiu and Lee (2011) point out, the focus of there and this paper specifically on the control over content pricing should not be viewed as the only source of difference in the surplus of consumers under the two regimes. In other words, their model (as well as this paper) could be in principle extended to account for additional incentives related to transferring control over content to content providers such as incentives to invest in content quality, sales efforts, etc. and not only on the control over content pricing.

Other few examples of non-price decisions analysis in two-sided markets include Hagiu and Wright (2014) who study the choice of intermediation mode (marketplace or reseller) depending on the trade-offs related to allocation of rights over non-contractible decisions between sellers and platforms; Hagiu and Jullien (2010) who analyze incentives to divert search by information intermediaries that enable buyers to search for affiliated sellers.

The main finding of this paper that platforms have an incentive to give control over content prices to content providers reminds the result of Bonanno and Vickers (1988) showing that vertical separation between manufacturer and retailer segments may relax price competition, leading to higher profits that manufacturers could extract from the retailers.

Section 2 describes the game that includes timing, consumer preferences, content providers and selection criterion used. Section 3 replicates the Hagiu and Lee's (2011) results for the case of exogenous control regimes in order to motivate incentives to choose control regime. Section 4 introduces the extended model and solves it. Section 5 concludes and discusses some business strategy implications of the obtained results.

2.2 Model

There are two competing two-sided platforms A and B who interact with consumers and content providers (denoted by C).

Let us call the model of Hagiu and Lee (2011) as *the basic model* and the model proposed here as *the extended model*.

The timing[2] of events is the same for the basic model and the extended model: first platforms determine conditions of interactions and bid for content, then observing those bids, content providers decide which platform to join (or join both or none), after that platforms and content providers (if they have control) set platform and content prices[3] and, finally, consumers decide which platform to participate in observing the prices of platforms, content allocation between the platforms and prices of content. The main difference between the basic model and extended model lies in what conditions of interaction with content providers can be chosen by the platforms in the first stage and what conditions platforms consider as given exogenously. Those differences are determined below in detail. We proceed by backward induction.

2.2.1 Consumer Participation Decisions

It is assumed that platforms are horizontally differentiated for consumers and not for content providers.

[2]The sequential timing of the game reflects a common situation in the software industries where commitment to deliver content in advance helps to solve chicken and egg problem, see Hagiu (2006) who focuses on the role of commitment in two-sided markets.

[3]As a first pass, the focus is on non-strategic content providers who do not internalize their price decision on the demand for platforms. That assumption could be justified in case of small content providers.

Consumers with a horizontal taste parameter θ distributed uniformly over $[0, 1]$ with a total number of consumers equal to one. Consumers experience horizontal differentiation cost of θt if they participate in platform A and $(1 - \theta)\, t$ if they participate in platform B; platforms A and B are situated at 0 and 1 points of this interval, respectively. Also, there is a platform stand alone value V derived by consumers and which is common for all consumers. It is assumed that both platforms, A and B, have the same stand alone value (platforms are symmetric) and it is high enough such that the whole market of consumers is covered.

In addition to common stand alone value, consumers derive a common surplus value $s\,(p)$ from the membership of each additional content provider, where p is the price of content. There are N content providers. In order to participate in a platform A, consumers have to pay participation (or access) price P_A and P_B - for platform B.

Consumers' utilities from platform A and B are:

$$u^A = V + N_A s\,(p_A) - \theta t - P_A$$

$$u^B = V + N_B s\,(p_B) - (1 - \theta)\, t - P_B$$

Thus, each consumer compares utilities from A and B in order to make a participation decision in A or B[4] Then, the demand for platform A and B will be determined by the number of types below and above the following marginal type $\widehat{\theta}$: $u^A = u^B$

$$\widehat{\theta} = \frac{1}{2} + \frac{N_A s\,(p_A) - N_B s\,(p_B) - P_A + P_B}{2t}$$

and demands for platform A and B that account for both the case of no tipping and case of a tipping in favor of one of the platforms are:

[4]It is assumed that platforms stand alone value perfectly substitute each other. Thus consumers have only unit demand for standalone value. Horizontal differentiation parameter may capture some first party content that is valued differently by different consumers.

$$D_A = \begin{cases} 0 & ,\text{if } \frac{1}{2} + \frac{N_A s(p_A) - N_B s(p_B) - P_A + P_B}{2t} < 0 \\ \widehat{\theta} & ,\text{if } 0 < \frac{1}{2} + \frac{N_A s(p_A) - N_B s(p_B) - P_A + P_B}{2t} < 1 \\ 1 & ,\text{if } \frac{1}{2} + \frac{N_A s(p_A) - N_B s(p_B) - P_A + P_B}{2t} > 1 \end{cases}$$

$$D_B = 1 - D_A$$

2.2.2 Platforms' and Content Providers' Consumer Pricing Decisions

Given allocation of content between platforms and conditions of that allocation (control over content pricing and whether content is exclusive or not) platforms and content providers (if they have control over content prices) maximize their profits subject to the anticipated demand of consumers. Without loss of generality marginal costs of platforms and content providers are set to zero.

In case when control over content prices belongs to platforms (it is called an outright sale regime of control), platforms maximize the sum of the profits from platforms and content as follows:

$$\Pi_A = \underset{P_A, p_A}{Max} \{D_A \cdot (P_A + N_A \pi(p_A))\} \text{ [5]}$$

where $\pi(p_A) = p_A d(p_A)$ is the profit from one piece of content and $d(p_A)$ is the demand for content. The same problem is for platform B. It is shown in Lemma 1 in Appendix that it is optimal in general for platform A (and B) to set content price equal to the marginal cost, i.e. $p_A = 0$ ($p_B = 0$). The intuition is that it is more profitable to increase the vertical quality of the platform by providing more surplus from content to consumers and then to extract it through higher platform access prices.

In case when control over content belongs to content providers (it is called affiliation control regime), platform A (and B) chooses only the price of access and the platform's problem is

[5]Notice, that throughout the paper the consumer demand is assumed to take the same form for every content and content is independent (no substitutability or complementarity between different contents), then every content will have the same price and consumers will consume the same amount of each content, then profits from content from one consumer are $\int_0^{N_A} p_A(i)\, d_i(p_A(i))\, di = \int_0^{N_A} p_A d(p_A)\, di = N_A p_A d(p_A)$

$$\Pi_A = \max_{P_A} \{D_A P_A\}$$

Content provider C's problem is

$$\Pi_C = \max_{p_C} \left\{\overline{D}\pi(p_C)\right\}$$

where $\pi(p_C) = d(p_C)\,p_C$ and $\overline{D}$ is the demand by consumers for the platform where C sells its content. Notice, that the bar (over D) indicated that C takes platform demand as given, assuming that C is relatively small[6]. So $\overline{D}$ could be omitted in the C's problem in this case.

2.2.3 Platforms' and Content Providers' Strategic Choice of Control and Exclusivity

Here the first stage of players interaction is described. The main difference between Hagiu and Lee (2011) and this paper is emphasized.

2.2.3.1 Basic Model

In the basic model, it is assumed that some conditions of interactions are given exogenous, while others are determined through a bidding game. The basic model considers the regime of control over content as given exogenously. That regime of control could take two forms: outright sale or affiliation. *Outright sale* control regime means that content provider transfers control rights over pricing (and cash flows from content) to platforms. *Affiliation* control regime means that content providers retain control over content pricing (and corresponding cash flows from content sales). Thus, in the basic model (where those regimes are not chosen but taken as given) the analysis is done separately for two regimes of control.

As mentioned above still in the basic model platforms may choose the following conditions of interaction: whether content provider joins the platform exclusively or multihome by conditioning

[6]Hagiu and Lee (2011) call this case a non-strategic content provider and relax this assumption by analyzing the implications of one strategic content provider and show that results could significantly change in this case. This possibility under considered extension is left for future research.

price of access to the platform on exclusivity/multihoming. Therefore, in the basic model platforms compete (it is called *a bidding game*) for the content by making simultaneously take-it-or-leave-it bids for content conditional on whether content joins the platform exclusively or not.

2.2.3.2 Extended model

In this paper, it is considered that platforms could also choose control regime during the bidding game in addition to exclusivity and, therefore, condition their bids on both dimensions (i.e., strategic control and exclusivity).

Extension of the model was motivated by the observation of Hagiu and Lee (2011) that there is a conflict of interests in the basic model, where platforms would prefer affiliation regime, while content providers would prefer the outright sale. Moreover, most important, that the sum of industry profits is higher under affiliation regime, Thus, participants could potentially engage in strategic bidding to choose the regime with the highest industry profit. This conjecture is formally studied in this paper by extending the first stage bidding game to condition platform bids over content not only on exclusivity but also on the regime of control.

In order to motivate incentives for the strategic choice of control the outcome of the basic model game is considered based on the simple example 3 from Hagiu and Lee (2011), and then equilibrium for the extended model is studied using the same example 3.

2.2.4 Content Providers' Coordination and Equilibrium Selection Criterion

In order to solve the basic model as in Hagiu and Lee (2011) it is assumed that content providers could coordinate on most efficient outcome from their joint perspective at the stage of the game where they make decisions to join the platforms. This is a "strong equilibrium refinement" (Aumann, 1959) and it allows to deal with potential multiplicity of Nash equilibria at the stage of content providers participation decisions by focusing on equilibria that are coalitionally stable among content providers[7].

For the purpose of making a clean comparison this paper follows Hagiu and Lee (2011) approach to select equilibria when there are multiple equilibria. The approach is the following: it is assumed that industry participants (platforms and content providers) could always coordinate on the equilibrium that has maximum industry profit. If there are multiple equilibria that generate maximum industry profit, then it is assumed that platforms are able to select equilibria that are best for platforms and worst for content providers.

2.3 Benchmark Results

Consider the simplest possible setting in order to derive basic intuition how the introduction of the possibility of strategic choice over control will shape the interaction in the market.

Such a simple setting corresponds to Example 3 in Hagiu and Lee (2011), where the valuation of content by consumers v is the same across consumers and consumers want to buy at most one unit of each content. Therefore, content provider that has control over content pricing is able to extract all consumer surplus ($s = 0$) by setting content price equal to the valuation of content by consumers ($p_C = v$). Therefore, under affiliation regime the content market is characterized by

$$p_C = v, \pi = v, s = 0$$

Under outright sale regime the content market is characterized by

$$p_C = 0, \pi = 0, s = v$$

[7] As noted in Hagiu and Lee (2011), it is not an objective of current framework to build a general model of multilateral bargaining with externalities that are explored in Segal (1999), Segal and Whinston (2003), de Fontenay and Gans (2007). Potential inefficiencies generated in stage 1 bargaining game are sensitive to assumptions governing agent beliefs, the transfer space, and the extensive form of the game; this paper abstracts from such frictions as a first pass. Incorporation of such frictions could be an interesting as well as challenging direction for future research. Prat and Rustichini (2003) and Bloch and Jackson (2007) provide conditions under which the industry efficient outcome will result in different bargaining games.

As discussed in previous section in general under outright sale platforms have incentive sell content for free (or at a marginal cost) and, thus, to attract more consumers and earn profit by raising platform access prices to consumers[8].

Also, for simplicity of calculations and exposition let us consider that the number of content available is one ($N = 1$) and horizontal differentiation parameter is one ($t = 1$).

2.3.1 What Are the Incentives to Choose Control?

As defined before, the game consists of two major stages. In the first stage the allocation of content providers between platforms happens on different possible conditions of interactions related to control and exclusivity. In the second stage, platforms compete in access prices for consumers and content prices are set either by platforms or content providers depending on the control regime. Let us proceed by backward induction.

There are two possible allocations of content in both regimes of content control: all content multihoming or all content is exclusive with one platform[9].

Each control regime is given exogenously and considered separately below.

2.3.1.1 Outright Sale

It is shown in the Appendix that the second stage profits of platforms are[10]

$$\Pi_P(0) = \frac{1}{2}$$

[8]In this particular example, total welfare from content is independent of content price and, thus, only the sum of content price and platform access price matters (see Lemma 1 and its proof in the Appendix). Thus, the content price could always be normalized to be equal zero and then to adjust accordingly platform access price.

[9]This is proved in Hagiu and Lee (2011) in their Proposition 1 under the assumption of the bidding game considered here as well as equilibrium refinement used. It means that the allocation of content that maximizes industry profit (subject to second stage price competition between content providers and platforms) is always an equilibrium outcome.

[10]Notice, there are no second stage profits of content providers as they do not have control over content pricing and cash flows.

$$\Pi_P(1) = J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}; v-1\right\}.^{11}$$

$$\Pi_P(-1) = I\{v<3\}\cdot\frac{\left(1-\frac{v}{3}\right)^2}{2}$$

where $\Pi_P(\Delta N)$ is the second stage platform profit given that this platform has ΔN more content than the rival[12]. Function $J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}; v-1\right\}$ is defined to take the value of first argument if $v < 3$ (no consumer tipping) and the second argument otherwise (consumer tipping).Function $I\{v<3\}$ takes the value 1 if $v < 3$ (no consumer tipping)and zero otherwise (consumer tipping).

The following table shows total industry profits for outright sale control regime in case of multihoming and exclusivity.

As seen from Table 1 industry profit is always higher under exclusivity as compared to multihoming. The reason is, on the one hand, is that under outright sale exclusivity creates strong vertical differentiation advantage for platform A as compared to platform B and, thus, platforms industry itself becomes more profitable. On the other hand, under multihoming platforms that have control over both content prices and platform access prices are tempted to undercut each other in both content prices and platform prices resulting to transferring all surplus from new content to consumers.

Next, given that the outcome of the second stage game is known, the first stage bidding game over content allocation is analyzed, and the equilibria of the whole game are characterized.

Potentially, there are two types of equilibria in the outright sale regime: exclusivity and multihoming. The conditions for them to occur are considered below.

[11] This formulation allows for competitive tipping. By competitive tipping it is meant a situation where because of quality advantage through exclusivity one platforms attracts all consumers, but is not able to set monopoly price as there is a competitive pressure from the potential entrant (so called competitive finge). Analysis of monoply tipping could be an interesting direction for future research. Demand for platforms can be used to show that there is no tipping for $v < 3$.

[12] Thus, in this particular example where N=1, $\Delta N = 0$ means multihoming; $\Delta N = 1$ - exclusivity in favor of the platform (A); $\Delta N = -1$ exclusivity in favor of the rival platform (B).

In the following analysis it is assumed a tie breaking rule in favor of the platform A, i.e., when content provider is indifferent whether to sign the exclusive contract with the platform A or B, the choice is A.

Exclusive outright sale equilibrium analysis in the basic model In order for exclusive (with A against B) equilibrium under outright sale regime to occur in the basic model, no player in the bidding game should have an incentive to deviate.

Content providers no deviation conditions[13]:

Participation condition for C

$$T_A^{e1} \geq 0 \tag{2.1}$$

Incentive compatibility conditions for C

$$T_A^{e1} \geq T_A^{m1} + T_B^{m1} \tag{2.2}$$

$$T_A^{e1} \geq T_B^{e1} \tag{2.3}$$

where T_A^{e1} is the bid of the platform A (superscript e means exclusivity condition, m - multihoming, 1 - outright sale, 2 (used later) - affiliation). Condition 2.1 is the participation condition for C. Condition 2.2 - incentive compatibility condition for C to prefer exclusivity with A than multihoming with both A and B. Condition 2.3 - incentive compatibility to stay exclusive with A rather than with B.

Platform A's no deviation (participation) condition:

[13] All no deviation conditions are classified into participation conditions and incentive compatibility conditions. Participation conditions for platforms reflect whether platform signs any contract (exclusive or not) and for content providers - whether they participate in the bidding game. Given a player participates, incentive compatibility conditions determine which control and exclusivity option are preferred.

$$J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}; v-1\right\} - T_A^{e1} \geq I\{v<3\} \cdot \frac{\left(1-\frac{v}{3}\right)^2}{2} \tag{2.4}$$

Platform B's no deviation ((non-) participation) condition:

$$I\{v<3\} \cdot \frac{\left(1-\frac{v}{3}\right)^2}{2} \geq J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}; v-1\right\} - T_B^{e1} \tag{2.5}$$

Notice, we only need to consider deviations by platforms that induce content providers to switch to another platform under exclusivity and do not need to consider deviations that induce multihoming as one platform cannot unilaterally induce multihoming in general (it is always possible to consider exclusive equilibria under assumption that $T_A^m \to -\infty$ or small enough and it is realized in such an equilibrium).

Conditions 2.3,2.4,2.5 imply:

$$T_A^{e1} = T_B^{e1} = \max\left\{\frac{2}{3}v; v-1\right\},$$

which constitute equilibrium bids together with T_A^{m1}, T_B^{m1} such that 2.2 is satisfied (for example, $T_A^m \to -\infty$).

Hence, there is a unique equilibrium allocation of industry profits between platforms and content providers under exclusive outright sale regime.

In this case exclusive agreement allows to vertically differentiate one platform and increase second stage industry profit, but all this additional profit and even more goes to C as a result of severe competition between platforms to get C exclusively in the first stage.

Multihoming outright sale equilibrium analysis in the basic model Consider no deviation conditions for content providers:

Participation condition for C

$$T_A^{m1} + T_B^{m1} \geq 0 \tag{2.6}$$

Incentive compatibility conditions for C

$$T_A^{m1} + T_B^{m1} \geq T_A^{e1} \tag{2.7}$$

$$T_A^{m1} + T_B^{m1} \geq T_B^{e1} \tag{2.8}$$

where 2.6 is a participation condition for C, while 2.7,2.8 state that there is no incentive for C to deviate to exclusive contracts either with A or with B.

For platform A:

Participation condition for A

$$\frac{1}{2} - T_A^{m1} \geq I\left\{v < 3\right\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2} \tag{2.9}$$

Incentive compatibility condition for A

$$\frac{1}{2} - T_A^{m1} \geq J\left\{\frac{\left(1 + \frac{v}{3}\right)^2}{2}, v - 1\right\} - T_A^{e1} \tag{2.10}$$

where 2.9 is platform A's participation condition in bidding for C, while 2.10 states that A has no incentive to attract C on the exclusive terms.

For platform B the constraints are analogous to A:

Participation condition for B

$$\frac{1}{2} - T_B^{m1} \geq I\left\{v < 3\right\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2} \tag{2.11}$$

Incentive compatibility condition for B

$$\frac{1}{2} - T_B^{m1} \geq J \left\{ \frac{\left(1 + \frac{v}{3}\right)^2}{2}, v - 1 \right\} - T_B^{e1} \tag{2.12}$$

Notice, that 2.7 and 2.10 imply:

$$T_A^{m1} + T_B^{m1} \geq T_A^{e1} \geq \max \left\{ \frac{\left(1 + \frac{v}{3}\right)^2}{2}, v - 1 \right\} - \frac{1}{2} + T_A^{m1},$$

which holds if and only if

$$T_B^{m1} \geq \max \left\{ \frac{\left(1 + \frac{v}{3}\right)^2}{2}, v - 1 \right\} - \frac{1}{2} \tag{2.13}$$

But 2.11 and 2.13 cannot hold at the same time - a contradiction (We can do similar comparisons of analogues conditions for C and platform B (2.8 and 2.12) and to achieve a contradiction by comparing those with 2.9). Thus, there is no outright sale multihoming equilibrium in the basic model.

Here the situation is similar to the prisoners' dilemma where platforms are two prisoners: if they could cooperate and not attract C exclusively, then they could have earned more (each platform earns $\frac{1}{2}$) than if they deviate, which results in outright sale equilibrium described in the previous section (where each platform earns $I\{v < 3\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2} < \frac{1}{2}, \forall v > 0$).

2.3.1.2 Affiliation

As shown in the Appendix under affiliation platforms' second stage profits are:

$$\Pi_P(0) = \frac{1}{2}$$

$$\Pi_P(1) = \frac{1}{2}$$

$$\Pi_P(-1) = \frac{1}{2}$$

Second stage profits of content providers:

$$\Pi_C(0) = v.$$[14]

$$\Pi_C(1) = \frac{v}{2}.$$[15]

where $\Pi_C(\Delta N)$ is the second stage content provider C's profit given that this content provider sells content for the platform that has ΔN more content than the rival platform ($\Delta N = 0$ means multihoming, $\Delta N = 1$ means exclusivity).

Notice, that the second stage profit of a platform in affiliation regime is $\frac{1}{2}$ and does not depend on whether the content is exclusive or not. This is a result of the combination of homogeneous content valuation extreme assumption (which means that content providers could extract all surplus from consumers) as well as C has control over content pricing. This will no longer be true in a more general setting.

Again, the combination of the assumption of affiliation regime and homogenous content valuation (full extraction of content surplus) leads to a situation where consumers tipping is impossible under exclusive affiliation.

The following table shows second stage industry profits under affiliation in case of multihoming and exclusivity.

It is seen from Table 2 that industry profit is always higher under multihoming affiliation as compared to exclusive affiliation. The reason is that, on the one hand, multihoming allows content to be sold to all consumers and, on the other hand, despite exclusivity, effectively due to homogenous

[14] This profit is $D_A\pi(p_C) + D_B\pi(p_C)$ which for the homogeneous content valuations gives $(D_A + D_B)v = v$

[15] This profit is $D_A\pi(p_C)$ and under the assumption of homogeneous content valuation $D_A = \frac{1}{2}$ and $\pi(p_C)$.

valuation of content preferences platform A does not gain any vertical differentiation advantage over platform B and, thus, does not create any additional platforms market profits.

Next, the first stage bidding game is analyzed in the basic model under affiliation. First, the existence of the exclusive type of equilibrium is checked and, then - multihoming type.

Exclusive affiliation equilibrium analysis in the basic model No player should have an incentive to deviate.

Content providers:

Participation condition for C

$$T_A^{e2} + \frac{v}{2} \geq 0 \tag{2.14}$$

Incentive compatibility condition for C

$$T_A^{e2} + \frac{v}{2} \geq T_A^{m2} + T_B^{m2} + v \tag{2.15}$$

$$T_A^{e2} + \frac{v}{2} \geq T_B^{e2} + \frac{v}{2} \tag{2.16}$$

Platform A:

Participation condition for A

$$\frac{1}{2} - T_A^{e2} \geq \frac{1}{2} \tag{2.17}$$

Platform B:

(Non-) Participation condition for B

$$\frac{1}{2} \geq \frac{1}{2} - T_B^{e2} \tag{2.18}$$

All conditions are analogues to the outright sale case analyzed above, but the profits numbers are different due change of control regime to affiliation.

Notice, 2.16,2.17 and 2.18 imply

$$T_A^{e2} = T_B^{e2} = 0$$

and all conditions are satisfied for small enough T_A^m.

Hence, there is a unique equilibrium allocation of industry profits under the case of exclusivity for affiliation control regime.

The situation here is different from the outright sale in the following way. Notice, that platforms' competition become softer when affiliation is allowed, and there is a homogenous valuation of content (content providers could extract all consumer surplus from content). The latter condition is important as it leads to no vertical differentiation effect between platforms from exclusivity. This allows platforms not to pay anything to content providers even though one of the platforms obtains content exclusively. On the other hand, exclusivity still allows content providers to earn profits only from selling content to the consumers of the exclusive platform and this profit is not extracted by the platforms due to competition for exclusivity.

Multihoming affiliation equilibrium analysis in the basic model Again, no player should have an incentive to deviate:

For content providers:

Participation condition for C

$$T_A^{m2} + T_B^{m2} + v \geq 0 \tag{2.19}$$

Incentive compatibility condition for C

$$T_A^{m2} + T_B^{m2} + v \geq T_A^{e2} + \frac{v}{2} \tag{2.20}$$

$$T_A^{m2} + T_B^{m2} + v \geq T_B^{e2} + \frac{v}{2} \tag{2.21}$$

For platform A:

Participation condition for A

$$\frac{1}{2} - T_A^{m2} \geq \frac{1}{2} \tag{2.22}$$

Incentive compatibility condition for A

$$\frac{1}{2} - T_A^{m2} \geq \frac{1}{2} - T_A^{e2} \tag{2.23}$$

For platform B:

Participation condition for B

$$\frac{1}{2} - T_B^{m2} \geq \frac{1}{2} \tag{2.24}$$

Incentive compatibility condition for B

$$\frac{1}{2} - T_B^{m2} \geq \frac{1}{2} - T_B^{e2} \tag{2.25}$$

Let us focus on symmetric equilibria where both platforms make the same multihoming bids

$$T_A^{m2} = T_B^{m2}$$

Participation condition for platforms 2.22 and 2.24 determine the upper bound on the multihoming bids

$$T_A^{m2} = T_B^{m2} \le 0$$

While participation condition for content providers 2.19 gives a lower bound on multihoming bids:

$$T_A^{m2} = T_B^{m2} \ge -\frac{v}{2}$$

Now let us check whether incentive compatibility conditions for C (2.20 and 2.21) and for platforms (2.23 and 2.25) are satisfied.

As easily seen from incentive compatibility conditions for platforms (2.23 and 2.25), a deviation does not change platform second period profits, and, thus, setting deviation bids (for exclusivity) equal to the equilibrium bids (multihoming)

$$T_A^{e2} = T_B^{e2} = T_A^{m2} = T_B^{m2}$$

will always satisfy those conditions. On the other hand incentive compatibility conditions for content providers (2.20 and 2.21) are satisfied, which could be shown by substitution of the above values into those conditions.

Hence, there are multiple multihoming equilibria allocations of industry profit between platforms and content providers with

$$-\frac{v}{2} \le T_A^{m2} = T_B^{m2} \le 0$$

As discussed in the previous section this paper follows Hagiu and Lee (2011) and uses an equilibrium selection criterion stating that in case of multihoming platforms could coordinate on the best for them (and the worst for content providers) equilibrium allocation, i.e.

$$T_A^{m2} = T_B^{m2} = -\frac{v}{2}$$

Notice, that in this case all profits from content are extracted from C by the platforms.

This section analysis is summarized in the following propositions:

Proposition 1. *(Hagiu and Lee (2011)). In the basic model with homogeneous consumer preferences for content, industry profit is always higher under affiliation than under outright sale (see Tables B.1 and B.2).*

Proposition 2. *(Hagiu and Lee (2011)). In the basic model with homogeneous consumer preferences for content, under outright sale regime there is a unique exclusive equilibrium where platforms' total profit is* $2 \cdot I\left\{v < 3\right\} \cdot \frac{\left(1-\frac{v}{3}\right)^2}{2}$ *and content providers' total profit is* $\max\left\{2\frac{v}{3}, v-1\right\}$*. Under the affiliation regime, there are multiple equilibria with highest industry profit coming from multihoming (see Table B.2). Under the equilibrium selection criterion that first picks the highest industry profit equilibrium and then chooses the one that is the best for platforms (and worst for content providers), platforms' total profit is* $1 + v$ *while content providers' total profit is* 0*.*

Proposition 3. *(Hagiu and Lee (2011)). According to Proposition 1 and 2 in the basic model with homogeneous consumer preferences for content, there is a conflict of interests regarding control regime between content providers and platforms: platforms would prefer affiliation regime that gives maximum possible industry profit of* $1 + v$*, while content providers would prefer the outright sale regime that generates less industry profit of* $J\left\{1 + \left(\frac{v}{3}\right)^2, v-1\right\}$*.*

2.4 Extended Model

As previous section shows that in a simple example with homogenous content preferences there is a conflict of interests between platforms and content providers regarding the choice of the control regime and there is a conjecture by Hagiu and Lee (2011) that the regime that maximizes industry profit will be chosen. This section extends the basic model by introducing strategic choice of content control where platforms determine both control and exclusivity conditions in the bidding game[16].

[16]It should be noted that if the parties could jointly sign a multilateral agreement, then it is pretty evident that maximal industry profit would be realized. However, this section considers a more realistic setting where there is no such a possibility (for example because of the possibility of antitrust sanctions or constantly changing economic environment where new content is constantly

As the second stage of the game is the same in both basic and extended model, this section focuses on the extended model first stage bidding game and characterizes equilibria for the whole game. Like in previous section four possible cases of the conditions of interactions are analyzed between the platforms and content providers, but now those conditions are entirely determined in the strategic bidding process.

2.4.1 Simplifying Assumptions

As a first pass let us simplify the extension maximally in order to be able to solve the extended model but still gain useful insights. First, let us assume that it is impossible for the content provider to be in outright sale regime with one platform and affiliation regime with another platform. That case could potentially happen only under multihoming equilibrium as content provider interacts with both platforms. It is assumed that the choice set of content providers does not have the option of choosing to multihome with A under outright sale and multihome with B under affiliation (and vice versa). It means, that whenever content provider wants to choose multihoming choice, it should choose either outright sale bids from both platforms or affiliation bids from both platforms.

Second, let us assume that (which is actually proved in the basic model by Hagiu and Lee (2011) in their Proposition 1) in extended model content providers being homogenous will make the same (symmetric) decisions in equilibrium (therefore, we rule out any equilibria where the same content providers could choose different options). It means that, on the one hand, it is assumed that either all content providers sign an exclusive contract with the same platform or all multihome. On the other hand, it is assumed that either all content providers choose outright sale regime, or all content providers choose affiliation regime.

As before all possible cases for control and exclusivity are considered below to check whether such equilibria exist and are they unique.

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changing vertical level of differentiation that makes it very difficult for platforms to collude) and platforms engage in severe strategic competitive process in determining conditions of interactions.

2.4.2 Exclusive Outright Sale Equilibrium Analysis in the Extended Model

No players of the game should have an incentive to deviate:

For content providers. Notice, that new no deviation conditions are added to the system below which are related to the possibility of deviation to affiliation regime of control for all players.

Participation condition for C

$$T_A^{e1} \geq 0 \tag{2.26}$$

Incentive compatibility conditions for C

$$T_A^{e1} \geq T_B^{e1} \tag{2.27}$$

$$T_A^{e1} \geq T_A^{e2} + \frac{v}{2} \tag{2.28}$$

$$T_A^{e1} \geq T_B^{e2} + \frac{v}{2} \tag{2.29}$$

$$T_A^{e1} \geq T_A^{m1} + T_B^{m1} \tag{2.30}$$

$$T_A^{e1} \geq T_A^{m2} + T_B^{m2} + v \tag{2.31}$$

For platform A:

Participation condition for A

$$J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}, v-1\right\} - T_A^{e1} \geq I\left\{v<3\right\} \cdot \frac{\left(1-\frac{v}{3}\right)^2}{2} \tag{2.32}$$

$$J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}, v-1\right\} - T_A^{e1} \geq \frac{1}{2} \tag{2.33}$$

Incentive compatibility condition for A

$$J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}, v-1\right\} - T_A^{e1} \geq \frac{1}{2} - T_A^{e2} \tag{2.34}$$

For platform B:

(Non-) Participation condition for B

$$I\{v<3\} \cdot \frac{\left(1-\frac{v}{3}\right)^2}{2} \geq J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}, v-1\right\} - T_B^{e1} \tag{2.35}$$

$$I\{v<3\} \cdot \frac{\left(1-\frac{v}{3}\right)^2}{2} \geq \frac{1}{2} - T_B^{e2} \tag{2.36}$$

There are two participation conditions for platform A stated above (2.32 and 2.33) as when platform A deviates and chooses not to participate in bidding, C may choose either outright sale exclusive option from B or affiliation exclusive option from B. The former case corresponds to the first participation condition 2.32, while the latter - to the second participation condition 2.33. Notice, that it is not required for both participation conditions to be satisfied as long as C never chooses option corresponding to the violated participation condition in equilibrium. Thus, we will have to analyze two cases (and, later, 4 cases for multihoming).

Case 1 ($T_B^{e1} \geq T_B^{e2} + \frac{v}{2}$) [If A decides not to participate in bidding, then C will prefer outright sale exclusive offer from B rather than affiliation exclusive offer from B]

In this case condition 2.33 is redundant in equilibrium as non-participation by A induces C to choose outright sale and, thus, the only participation condition that A should care about is 2.32.

Incentive compatibility condition 2.27 for C and participation conditions for A and B, 2.32 and 2.35, imply

$$T_A^{e1} = T_B^{e1} = \max\left\{2\frac{v}{3}, v-1\right\}$$

Then, incentive compatibility condition for C 2.29 and (non-) participation condition for B 2.36 imply for T_B^{e2}:

$$\frac{1}{2} - I\{v < 3\} \cdot \frac{\left(1-\frac{v}{3}\right)^2}{2} \leq T_B^{e2} \leq \max\left\{\frac{v}{6}, \frac{v}{2} - 1\right\}$$

This condition (as well as the assumption of Case 1) could be satisfied only for the case of outright sale consumer tipping ($v > 3$). The same implication appears for conditions 2.28 and 2.34 for T_A^{e2} (these conditions are equivalent to 2.29 and 2.36 as is easily seen after substitution of T_A^{e1} into 2.34). Conditions 2.30 and 2.31 will always hold if multihoming bids are set sufficiently low.

Case 2 ($T_B^{e1} < T_B^{e2} + \frac{v}{2}$) [If A decides not to participate in bidding, then C will prefer affiliation exclusive offer from B rather than outright sale exclusive offer from B]

In this case A's participation condition 2.32 is redundant, and A's participation condition 2.33 is relevant.

Notice, that participation conditions for A and B, 2.33 and 2.35, imply for any v that

$$T_B^{e1} > T_A^{e1},$$

which contradicts incentive compatibility condition 2.27 for C since content provider would prefer the offer of B instead of A.

To summarize, in the extended model exclusive outright sale equilibrium exists only for $v > 3$ (corresponds to a outright sale consumer tipping in favor of A).

Notice the difference of extended model as compared to basic model where outright sale equilibrium exists for any v. In the extended model additional incentive compatibility constraints are added related to possibility of deviation to affiliated exclusive contracts. For values of content $v < 3$ this creates incentives of platforms to soften bidding for content by inducing content to affiliate. The main reason for softening of the competition for content lies in the fact that under affiliation content creates less vertical differentiation of exclusive content as transferring control to monopolist content provider guarantees high content prices. The reason this deviation is impossible for $v > 3$ is that outright sale allows content providers to extract the whole industry profit and, thus, no platforms have enough resources to make a deviation to exclusive affiliation attractive for content providers.

The findings are summarized in the following proposition.

Proposition 4. *Under the extended model with the homogeneous content valuation outright sale (either exclusive or multihoming) could never be an equilibrium for $v < 3$ (no consumer tipping condition for outright sale regime). For $v > 3$ (outright sale consumer tipping), the outright sale is an equilibrium.*

2.4.3 Multihoming Outright Sale Equilibrium Analysis in the Extended Model

The analysis of multihoming outright sale equilibrium is very similar to the basic model as the system contains the same conditions as in the basic model plus some additional related to the ability of platforms to choose regime of control and content providers to have more options to choose. Thus, the same contradiction as in basic model proves that in the extended model there is no multihoming outright sale equilibrium. Hence, the proposition. Notice, there is a difference of interpretation of this deviation under the extended model as compared to the basic model. In the basic model, this situation was interpreted as the prisoner's dilemma as deviation resulted in outright sale exclusive equilibrium that gives platforms less profit than multihoming outright sale option. Since in the extended model platforms can choose control regime, they may deviate and find themselves in a potentially better affiliation multihoming equilibrium which is studied next.

Proposition 5. *Under extended model with homogeneous content valuation there are no outright sale multihoming equilibria as in the basic model (and for the same reason since there is always an incentive for platforms to deviate and attract content exclusively). Under the extended model, the prisoner's dilemma interpretation of outright sale multihoming case becomes less relevant* *since after a deviation platforms may find themselves in an even better situation (like multihoming affiliation as will be shown later).*

2.4.4 Exclusive Affiliation Equilibrium Analysis in the Extended Model

In order for an exclusive affiliation equilibrium to exist, no player should have an incentive to deviate.

For content providers

Participation condition for C

$$T_A^{e2} + \frac{v}{2} \geq 0 \tag{2.37}$$

Incentive compatibility conditions for C

$$T_A^{e2} + \frac{v}{2} \geq T_B^{e1} \tag{2.38}$$

$$T_A^{e2} + \frac{v}{2} \geq T_A^{e1} \tag{2.39}$$

$$T_A^{e2} + \frac{v}{2} \geq T_B^{e2} + \frac{v}{2} \tag{2.40}$$

$$T_A^{e2} + \frac{v}{2} \geq T_A^{m1} + T_B^{m1} \tag{2.41}$$

$$T_A^{e2} + \frac{v}{2} \geq T_A^{m2} + T_B^{m2} \tag{2.42}$$

For platform A:

Participation condition for A

$$\frac{1}{2} - T_A^{e2} \geq I\{v < 3\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2} \tag{2.43}$$

$$\frac{1}{2} - T_A^{e2} \geq \frac{1}{2} \tag{2.44}$$

Incentive compatibility condition for A

$$\frac{1}{2} - T_A^{e2} \geq J\left\{\frac{\left(1 + \frac{v}{3}\right)^2}{2}, v - 1\right\} - T_A^{e1} \tag{2.45}$$

For platform B:

(Non-) Participation condition for B

$$\frac{1}{2} \geq J\left\{\frac{\left(1 + \frac{v}{3}\right)^2}{2}, v - 1\right\} - T_B^{e1} \tag{2.46}$$

$$\frac{1}{2} \geq \frac{1}{2} - T_B^{e2} \tag{2.47}$$

Case 1 ($T_B^{e2}+\frac{v}{2} > T_B^{e1}$) [Optimistic platforms' expectations[17]: If A decides not to participate in bidding, then C will prefer affiliation exclusive offer from B rather than outright sale exclusive offer from B]

One of platform A's participation conditions, 2.43, is redundant!

As before, the conditions for equilibrium bids are checked first: participation conditions for platforms (2.44 and 2.47) and incentive compatibility condition for C, 2.40, imply

$$T_A^{e2} = T_B^{e2} = 0$$

[17] As will be shown later such an expectation is always better for platforms and worse for content providers. Hence the title: optimistic (for) platforms expectations.

Then, it is checked whether there is an incentive by all parties to deviate to other options: incentive compatibility for content providers 2.38, participation condition 2.46 for the platform B and Case 2 condition imply:

$$J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}, v-1\right\} - \frac{1}{2} \leq T_B^{e1} < \frac{v}{2}$$

This condition is satisfied only for $v < 3$!

Exactly the same conditions are obtained for incentive compatibility conditions of content providers and of the platform A (2.39 and 2.45):

$$J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}, v-1\right\} - \frac{1}{2} \leq T_A^{e1} \leq \frac{v}{2}$$

As easily seen the rest conditions are satisfied if multihoming bids are set to be sufficiently low.

In this case we get an equilibrium like in the basic model, but for basic model this equilibrium held for any v. Under extended model for $v > 3$ this equilibrium does not hold anymore as for too high content valuation there is an incentive to deviate to exclusive outright sale. This deviation would create consumer tipping in the industry and will allow to extract all industry profit by deviating parties. Under not too high content valuation, $v < 3$, exclusive outright sale contract generates not enough profits to make such a deviation profitable.

Notice, there is no other than $T_A^{e2} = T_B^{e2} = 0$ equilibrium (only for $v < 3$) allocations under Case 1.

Case 2 ($T_B^{e2} + \frac{v}{2} \leq T_B^{e1}$) [Pessimistic platforms' expectations: if A decides not to participate in bidding, then C will prefer outright sale exclusive offer from B rather than affiliation exclusive offer from B]

In this case only A's participation condition 2.43 is relevant (and 2.44 is redundant).

Notice, that compared to previous case, the only difference in the system of equilibrium conditions is that the right hand side of participation condition of platform A has decreased (compare 2.44 versus 2.43), as platform A expects a more pessimistic outcome from non-participation since

C will join B with outright sale exclusive contract and will allow B to more significantly vertically differentiate itself as compared to A. This means, that A in Case 2 in equilibrium would tolerate paying higher bid as compared to Case 1 analyzed before. Together, participation conditions for platforms (2.43 and 2.47) and incentive compatibility condition for content providers 2.40 imply

$$0 \leq T_B^{e2} \leq T_A^{e2} \leq \frac{1}{2} - I\{v < 3\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2}$$

Notice, that all conditions are the same for B as in the previous case and the new participation condition 2.43 tends to make A even more attractive for C than it was in Case 1. Thus, it is only required to check whether A and C will not have an incentive to deviate and there is no need to worry that B will deviate if the bids for B are set exactly the same as they were set for Case 1 above.

Now, in order to A and C not to have incentives to deviate, both incentive compatibility conditions 2.39 for C and 2.45 for A, stating that both will not prefer outright sale exclusive option, should hold. Both conditions imply

$$J\left\{\frac{\left(1 + \frac{v}{3}\right)^2}{2}, v - 1\right\} - \frac{1}{2} \leq T_A^{e1} - T_A^{e2} \leq \frac{v}{2}$$

which could hold only for $v < 3$.

Therefore, there are many affiliation exclusive equilibria as shown above with

$$0 \leq T_A^{e2} \leq I\{v < 3\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2}$$

and B bidding, for example, like in Case 1.

Thus, in addition to unique basic Hagiu and Lee (2011) model equilibrium with $0 = T_A^{e2} = T_B^{e2}$, extended model allows exclusive equilibria with positive bids for C for $v \leq 3$ and there are no equilibria for $v > 3$.

The intuition for why there are no equilibria for extended model Case 2 for $v > 3$ is the same as in the Case 1 above.

The intuition for why there could be additional equilibria for extended model in Case 2 for $v \leq 3$ is the following. If platform A has a pessimistic expectations (Case 2 - that if it deviates to no participation, then exclusive outright sale regime with B will occur), then it allows for C to extract positive bids from A. One can interpret it as pessimistic expectations of A increases bargaining power of C to extract surplus from A[18].

The findings are summarized in the following proposition.

Proposition 6. *Under the extended model with homogeneous content valuation, there are multiple exclusive affiliation equilibria[19] that correspond to pessimistic expectations of platform A regarding actions of C in case of A's deviation. In pessimistic expectations equilibria, A expects C to choose outright sale option from B after A's deviation and, thus, C can get positive bids from A and payoff of A is less than of B (who do not participate). Nevertheless, assumed selection criterion allows avoiding those pessimistic expectations equilibria by the platforms.*

2.4.5 Multihoming Affiliation Equilibrium Analysis in the Extended Model

No player should have an incentive to deviate.

For content providers:

Participation condition for C

$$T_A^{m2} + T_B^{m2} + v \geq 0 \tag{2.48}$$

Incentive compatibility conditions for C

$$T_A^{m2} + T_B^{m2} + v \geq T_B^{e1} \tag{2.49}$$

[18]Notice, in this case B, by not signing an exclusive contract with C, earns more than A.

[19]Notice, in the basic model there is a unique exclusive affiliation type of equilibrium.

$$T_A^{m2} + T_B^{m2} + v \geq T_A^{e1} \tag{2.50}$$

$$T_A^{m2} + T_B^{m2} + v \geq T_A^{e2} + \frac{v}{2} \tag{2.51}$$

$$T_A^{m2} + T_B^{m2} + v \geq T_B^{e2} + \frac{v}{2} \tag{2.52}$$

For platform A:

Participation condition for A

$$\frac{1}{2} - T_A^{m2} \geq I\left\{v < 3\right\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2} \tag{2.53}$$

$$\frac{1}{2} - T_A^{m2} \geq \frac{1}{2} \tag{2.54}$$

Incentive compatibility conditions for A

$$\frac{1}{2} - T_A^{m2} \geq \frac{1}{2} - T_A^{e2} \tag{2.55}$$

$$\frac{1}{2} - T_A^{m2} \geq J\left\{\frac{\left(1 + \frac{v}{3}\right)^2}{2}, v - 1\right\} - T_A^{e1} \tag{2.56}$$

For platform B:

Participation condition for B

$$\frac{1}{2} - T_B^{m2} \geq I\left\{v < 3\right\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2} \tag{2.57}$$

$$\frac{1}{2} - T_B^{m2} \geq \frac{1}{2} \tag{2.58}$$

Incentive compatibility conditions for B

$$\frac{1}{2} - T_B^{m2} \geq \frac{1}{2} - T_B^{e2} \tag{2.59}$$

$$\frac{1}{2} - T_B^{m2} \geq J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}, v-1\right\} - T_B^{e1} \tag{2.60}$$

As for other cases for extended model there are two participation conditions for each platform depending on platforms expectations of C's choice after platforms' deviations. It means, at least one of conditions 2.53 and 2.54 needs to be satisfied for platform A and expected choice of C should be realized in equilibrium. The same holds for participation conditions 2.57 and 2.58 for platform B.

Thus, in general there are 4 possible cases:

$$\text{Case 1} \left(T_A^{e1} \leq T_A^{e2} + \frac{v}{2}; T_B^{e1} \leq T_B^{e2} + \frac{v}{2}\right)$$

$$\text{Case 2} \left(T_A^{e1} \geq T_A^{e2} + \frac{v}{2}; T_B^{e1} \geq T_B^{e2} + \frac{v}{2}\right)$$

$$\text{Case 3} \left(T_A^{e1} \geq T_A^{e2} + \frac{v}{2}; T_B^{e1} \leq T_B^{e2} + \frac{v}{2}\right)$$

$$\text{Case 4} \left(T_A^{e1} \leq T_A^{e2} + \frac{v}{2}; T_B^{e1} \geq T_B^{e2} + \frac{v}{2}\right)$$

As before, first, the focus is on the simpler Case 1, that is more similar to the basic model. Then, Case 2 is considered and Case 3 and 4 are omitted as they do not add anything under the assumption of symmetric multihoming bids ($T_A^{m2} = T_B^{m2}$).

Case 1 $\left(T_A^{e1} \leq T_A^{e2} + \frac{v}{2}; T_B^{e1} \leq T_B^{e2} + \frac{v}{2}\right)$**[Optimistic platforms' expectations: if any platform decides not to participate in bidding, then C will prefer affiliation exclusive offer from the other (participating) platform rather than outright sale exclusive offer from the other (participating) platform]**

In this case the only relevant participation conditions for A and B are 2.54 and 2.58, respectively, and 2.53 and 2.57 are redundant.

Like in the basic model, first, it is verified whether no deviation conditions for equilibrium (multihoming) bids are satisfied. For symmetric multihoming bids, the participation condition for content providers 2.48 implies:

$$T_A^{m2} = T_B^{m2} \geq -\frac{v}{2}$$

On the other hand, participation conditions for platforms A and B, 2.54 and 2.58, respectively, imply

$$T_A^{m2} = T_B^{m2} \leq 0$$

No deviation to exclusive affiliation conditions (incentive compatibility conditions 2.51, 2.52 for C and 2.55 and 2.59 for A and B, respectively) for all players will be satisfied if T_A^{e2}, T_B^{e2} are set as in the basic model.

Next, notice that there are additional incentive compatibility constraints (2.49, 2.50 for C and 2.56 and 2.60 for A and B, respectively) for all players, related to the possibility of deviation to exclusive outright sale contract, that should be satisfied. Let us check conditions for A and C (for B and C they are identical). Incentive compatibility conditions for C and A, 2.50 and 2.56, respectively, imply

$$J\left\{\frac{\left(1+\frac{v}{3}\right)^2}{2}, v-1\right\} - \frac{1}{2} \leq T_A^{e1} - T_A^{m2} \leq T_B^{m2} + v$$

Satisfaction of this condition will depend on the value of T_B^{m2}. For example, if $T_B^{m2} = 0$, corresponding to no extraction of rent from content providers by the two platforms, this condition will hold for any $v > 0$. Notice that if $T_B^{m2} < -\frac{3}{2}$ then this condition could not hold for any $v > 0$. Also, for $v > 3$ maximum rent extracted by a platform from content providers such that this condition holds is $T_B^{m2} = -\frac{3}{2}$. For $v \leq 3$ setting $T_B^{m2} = -\frac{v}{2}$ will satisfy this condition.

Thus, it is found that for low and medium content valuations $v < 3$ (no consumer tipping in the outright sale regime) platforms could extract all content profits, but for high content valuations $v > 3$ (consumer tipping in the outright sale regime) platforms could not extract all profits from content, maximum each platform could extract is $\frac{3}{2}$, and content providers still get a significant amount of content profits, i.e. $v - 2 \cdot \frac{3}{2} = v - 3$. In contrast, in the basic model all equilibria sets were independent of the value of content v, and all profits extraction from C is always an equilibrium. While in the extended model, such types of equilibria exist only for $v < 3$ and do not exist for $v \geq 3$.

Case 2 $\left(T_A^{e1} > T_A^{e2} + \frac{v}{2}; T_B^{e1} > T_B^{e2} + \frac{v}{2}\right)$**[Pessimistic platforms' equilibria: if any platform decides not to participate in bidding, then C will prefer outright sale exclusive offer from the other (participating) platform rather than affiliation exclusive offer from the other (participating) platform]**

In this case the only relevant participation conditions for A and B are 2.53 and 2.57, respectively, while 2.54 and 2.58 are redundant.

Notice, the analysis is very similar to exclusive affiliation equilibrium case. Because, both A and B may have pessimistic expectations regarding reaction of C to a non-participation of platforms, there will be equilibria where A and B will make actually positive bids to C, or pay to C! That could be seen from participation conditions for C and A, 2.48 and 2.53, respectively (similarly for 2.48 and 2.57), that imply

$$-\frac{v}{2} \leq T_A^{m2} = T_B^{m2} \leq \frac{1}{2} - I\{v < 3\} \cdot \frac{\left(1 - \frac{v}{3}\right)^2}{2},$$

where the right hand side is positive for $v > 0$.

The rest of the analysis of the system proceeds exactly the same as in Case 1.

Therefore, additional implication coming from extended model is that there are additional equilibria related to pessimistic expectations of platforms which additionally reward content providers. Notice, though, that under the assumed selection criterion such equilibria are ruled out as it is assumed that platforms could always coordinate on the best equilibria for them. Nevertheless, if for some reason they cannot coordinate, additional equilibria with excessive content reward may be realized even for $v < 3$ and platforms may find themselves in a situation similar to outright sale equilibrium in the basic model where platforms would prefer that content providers did not exist in the market since their existence creates destructive competition between the platforms for content.

The findings of this section and the answers to the paper's main questions of are summarized below.

Proposition 7. *Under the extended model with homogeneous content valuation, there are additional equilibria corresponding to pessimistic expectations of platforms that content providers will choose exclusive outright sale contracts with the rival platform when the platform deviates. These pessimistic platforms' expectations allow content providers to extract positive bids from platforms under multihoming affiliation, a situation that could have never occurred in the basic model. Nevertheless, equilibrium selection criterion allows platforms to avoid those pessimistic expectations equilibria.*

Proposition 8. *Under extended model (with homogeneous content valuation) for affiliated multihoming, the maximum share of content profits that platforms could extract depends (weakly negatively) on v. For $v < 3$ (no consumer tipping under outright sale), all profits from C could be extracted, for $v > 3$ (consumers tipping under outright sale) not all profit from C is extracted: maximum that can be extracted by each platform is $\frac{3}{2}$ and, thus, $v - 2 \cdot \frac{3}{2}$ is guaranteed to be earned by content providers. This holds even for selection criterion used by Hagiu and Lee (2011) and is in contrast to the basic model where platforms can extract all profits from content providers for any v.*

Proposition 9. *Under extended model with homogeneous content valuation and with a selection criterion used by Hagiu and Lee (2011), strategic bidding game over control and exclusivity leads* *to the multihoming affiliation equilibrium that maximizes second stage industry profit. In general (without applying equilibrium selection) under the extended model with homogeneous content valuation exclusive affiliation equilibria exist only for* $v < 3$, *and for* $v \geq 3$ *exclusive outright sale equilibrium exists (and unique for this type) while multihoming equilibria exist for any* $v > 0$. *For all values* $v > 0$ *multihoming equilibria bring higher total industry profits.*

2.5 Conclusions

This paper addressed the question of the role of strategic choice of control in addition to exclusivity for the outcome of two-sided platforms' competition. A specific but benchmark case of homogeneous content preferences was considered. As suggested in Hagiu-Lee (2011) it is demonstrated there is a conflict of interests between content providers and platforms regarding the regime of control that is given exogenously. Content providers would prefer outright sale regime and platforms would prefer affiliation regime that maximizes industry profit. An extended model considered in this paper allows platforms to strategically choose the regime of control in addition to exclusivity through a bidding game.

The following insights are obtained from the extended model with endogenous control under the specific case of homogeneous content preferences.

First, in contrast to the basic model with exogenous control of Hagiu and Lee (2011), there are no outright sale exclusive equilibria for low and medium levels of content valuation (for which there is no consumer tipping under outright sale) when platforms could condition bids for content on the regime of control. Deviation by platforms to affiliation works as a commitment to charge higher prices for content and, thus, to reduce vertical differentiation from exclusive content and, thus, to soften platforms' competition for content in the bidding stage. Thus, for low and medium content valuations there are only affiliation equilibria (multiple exclusive and multiple multihoming), and multihoming corresponds to the maximum industry profits.

Second, for high content valuation (consumer tipping under outright sale) there is one exclusive outright sale equilibrium, and multiple multihoming equilibria and the latter correspond to the maximum industry profits. In contrast to the basic model, in the extended model, the minimum content providers' payoff is positive and linearly increases with the degree of content valuation. The reason for the guaranteed reward for high valuation content providers is that if high valuation content providers are not rewarded enough, any platform has a temptation to propose an exclusive outright sale option that content provider will accept if not rewarded enough in the first place. Because such a deviation will create a significant vertical differentiation effect for the platform, unless platform will not have to pay too much to the content provider to induce such a deviation, any platform will prefer to deviate. In contrast, in the basic model exogenous affiliation serves as a commitment for high content prices that results in no vertical differentiation between the platforms which prevents the temptation by platforms to attract content providers even if it is very cheap to do that given that in multihoming equilibrium all content profits are extracted.

Third, the extended model is characterized by additional as compared to basic model affiliation equilibria (both exclusive and multihoming) that result from possible platforms' pessimistic expectations that content providers will choose exclusive outright sale and not exclusive affiliation option from the rival when the platform deviates and not participates in the bidding for content. As emphasized before, exclusive outright sale contract with the rival platform reduces the platform's profit much more than affiliation outright sale contract with the rival platform, due to higher vertical differentiation effect between platforms for exclusive outright sale contract. In such pessimistic expectations affiliation equilibria, content providers could extract additional profits from platforms as compared to basic model. Nevertheless, if platforms could coordinate (selection criterion applies), then such equilibria could be avoided by the platforms.

Therefore, the question of who will win or lose from the introduction of the possibility to choose the content control regime by the platforms depends on several circumstances.

First, if initially the industry is characterized by exogenous outright sale regime (like possibly satellite TV or Radio) where exclusive content is the equilibrium outcome, then independent of content valuation (with or without consumer tipping) platforms could benefit if they could choose control regime. An essential condition for this is the possibility by platforms to coordinate on equilibria that maximize industry profit and which are best for platforms (selection criterion applies). Thus, if platforms could successfully coordinate, then the welfare of content providers will undoubtedly decrease as compared to the initial situation of exogenous outright sale regime, while the welfare of platforms will increase. On the other hand, if platforms' ability to coordinate is limited, and especially if platforms have pessimistic expectations, then there are higher chances for content providers to improve their situation or at least to have some reward under affiliation regimes (either exclusive or multihoming) that will be realized in equilibrium.

Second, consider the initial situation of an industry characterized by exogenous affiliation (which could be possible in the video game industry), and platforms could successfully coordinate on the multihoming outcome and extract all industry profits. Then for low and medium content valuation introduction of the possibility to choose control by the platforms will not change the market outcome. On the other hand, if the exclusive content valuation is very high, the introduction of endogenous control will significantly redistribute content profits from platforms to content providers. Thus, such an analysis indicates that for high valuation content industries platforms will have incentives to maintain affiliation commitment as much as they can (for example by increasing technological costs of switching to outright sale control regime) in order extract most high valuation content providers profits. Besides, as before, if platforms could not perfectly coordinate, then the introduction of endogenous control regime could improve content providers bargaining power due to pessimistic platforms' expectations. This should additionally motivate platforms to avoid making control endogenous.

The next important step is to generalize the extended model to arbitrary preferences over content and to consider strategic pricing by content providers.

A potentially interesting extension is to incorporate other benefits and costs of the two control regimes as analyzed in Hagiu (2007) and explore predictions of the model in that case. Such decisions could be related to advertising expenditures, investments in improving the quality of the content or distribution channels, etc.

CHAPTER 3

LONG TERM EFFECTS OF MINIMUM DRINKING AGE LAWS ON ORGAN FAILURE (CO-AUTHORED WITH DR. MINH NGUYEN)

3.1 Introduction

Most of the 20th century, after Prohibition was repealed in 1933, in most states, the minimum legal drinking age (MLDA) in the United States was 21 years. However, the Vietnam War in the 1960s and 1970s, when many 18-year-olds were drafted, and the ongoing increase of the role of young people in the civil rights movement, social and political change movements of the 1950s and 1960s, increased pressure to give youth more rights which included earlier voting, earlier age of majority, and earlier drinking age. More than 30 states lowered the drinking age below 21 during the early 1970s. By the mid-1970s and early 1980s, several influential research publications appeared such as (Williams et al. (1975), Williams et al. (1983), Cook and Tauchen (1984)) demonstrating that states that lowered MLDA experienced more youth traffic-related fatalities, while states which increased MLDA experienced less youth traffic-related fatalities. These research and civil pressures were an important motivation for Ronald Reagan, although he was initially opposed, to introduce National Minimum Drinking Age Act in 1984 which required states to set MLDA at 21, otherwise, they would lose 10% of federal highway funds. That law resulted in all states setting the drinking age to 21 by 1988.

These events created a great research opportunity and resulted in numerous publications on the effects of changes in drinking laws on different outcomes of primary interest at that time, which were related to the immediate effect of MLDA laws on the traffic crashes involving youth and, related, alcohol consumption by youth summarized in Wagenaar and Toomey (2002). Despite a consensus[1] among most researchers that setting MLDA back to 21 was a most reasonable policy

[1]Wagenaar and Toomey (2002) identified 241 empirical articles on the topic and concluded that although about half of research papers found insignificant effects, the other half in 90% of cases showed that increasing MLDA to 21 had lead to a statistically significant reduction in both alcohol

saving significant numbers of lives[2], the debate in the public continues and there are opinions that MLDA should be lowered again[3].

In this paper, we are looking at less direct, or immediate, however very potentially important connection between minimum legal drinking age and demand for organ transplants in the United States. To our knowledge, it is the first paper that analyzes such an outcome. It is an emerging area of study. Several recent papers also look at the long-term, less visible, effects of MLDA laws on such outcomes as alcohol and drug abuse disorders in later life (Norberg et al. (2010)), on adult (who were adolescents when the MLDA laws changed) alcohol use and driving fatalities (Kaestner and Yarnoff (2011)), suicide and homicide deaths among women (Grusza et al. (2012)), binge drinking later in life (Plunk et al. (2013)), high school dropouts (Plunk et al. (2015)), alcohol-related chronic disease mortality (Plunk et al. (2016)). This research demonstrates that MLDA laws should be considered in a much broader context than just immediate effects. Given that enough time has passed since MLDA changes, we have an opportunity to study such long-term effects of MLDA to be able to estimate more accurately the benefits and costs of allowing youth to

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consumption and traffic fatalities among youth.

[2]However, there is one relatively recent paper by Miron and Tetelbaum (2009) that questions if the National Minimum Drinking Age Act actually saved lives.

[3]There were recently many attempts to lower MLDA below 21. In 2008 Missouri, South Dakota, Vermont and Minnesota considered lowering MLDA below 21 for general population, while Kentucky, Wisconsin and South Carolina have introduced legislation that would lower the drinking age only for military personnel (see https://abcnews.go.com/US/Politics/story?id=4577105page=1). Recently, in 2016, New Hampshire, Minnesota and California proposed legislation to lower MLDA (see https://www.entrepreneur.com/article/269537). All these attempts never were successful at lowering MLDA for general population, however some proposals to relax legislation for certain subgroups of population were successful (see https://drinkingage.procon.org/states-that-allow-underage-under-21-alcohol-consumption/, states where there are exceptions for MLDA21 rule for religious, medical purposes, or when drinking in the presence of parents among other exceptions). Another example of a campaign was launched in 2008 in favor of reconsidering MLDA21 is Amethyst initiative where more than 100 presidents of US colleges suggested reconsidering the MLDA21 policy, which in practice was perceive by the public as advocating for lowering MLDA below 21 (see https://fordhamobserver.com/1832/news/amethyst-initiative-questions-21-year-old-drinking-age/). Their main argument is that MLDA21 policy is less effective, or even counterproductive on campuses, and promotes more binge drinking than it would have been otherwise. Their quality of research of specific populations as a college population is poor, preventing any conclusions based on actual data (see discussion in Wagenaar and Toomey (2002)).

drink early.

Conceptually lower MLDA could lead to excessive consumption of alcohol, not just at age of 18-20, but throughout the whole life, which may lead to liver and other organs failure and the need for organ transplants at some point during their life. There is some preliminary evidence that lower MLDA results in more binge drinking and less moderate drinking among adults (see Plunk et al. (2013)). On the other hand, although sometimes ignored in policy debate since relies on using animal experiments, neurological biology shows (see Chambers et al (2003)) that parts of the brain responsible for addiction resistance are still forming during ages 18-20 and at the same time at that age range adolescents prefer to experiment to learn new things (including trying alcohol and binge drinking), a combination that could lead to alcohol addiction and subsequent need for organ transplantation.

There are potential empirical challenges in identifying the causal effect of drinking age laws changes on organ transplantation outcomes. Although MLDA changes are an example of a natural experiment, to reveal the causal effect, a good empirical strategy must be employed. For example, MLDA policy in a particular state may be a response to the changing economic, political, and social factors affecting alcohol consumption behavior which in turn determines future organ demand and confounding our estimates.

Our method uses variation in the timing of state laws enabling the population of 18-20 youth to get access to alcohol in some years and prohibiting this age group from getting access to alcohol in other years. We use fixed state effects to take into account any unobserved factors that could be different across states (as a taste for alcohol) and stable across different cohorts living in a particular state. On the other hand, cohort fixed effects take into account any cohort-related trends that are common across states. We use event study methodology which has the advantage of testing the existence of pretends and hence giving more credibility in identifying causal effects of the policy. This is very important given that MLDA changes happened in both economically, politically, and culturally dynamic times.

3.2 Background on Organ Transplantation in the US

According to European Directorate for Quality of Medicine which collects international data on organ transplantation activity and organ waitlists in 2018, compared to other OECD countries, the United States is the second country, after Spain, in the number of transplants per million of population. Not only US is the leader in terms of transplantation activity, it is also second, after Turkey, in terms of the number of people waiting for an organ per million of population and in terms of the number of people who die per million of population while being on the waiting list for an organ.

In 1984, a United Network for Organ Sharing (UNOS) was established to manage Organ Procurement and Transplantation Network (OPTN) which coordinates organ transportation by maintaining a database of all transplant candidates and donors for different types of organs.

Although the population of 18-20 years old constitutes a small portion of the overall population, over time every person who becomes of that age is affected by the law, and in the long term changes in MLDA laws affect the whole population. Hence any policy evaluation should take into account the long-run effects of such a policy.

Any behavior leading to the need for organs is potentially very costly for society. For example, in 2010 the cost of one kidney transplant was about a half-million dollars. Moreover, since there is a significant deficit of organs, any policy leading to a reduction of people on the waitlist saves lives since it would increase the number of donated organs per person on the waiting list.

3.3 Data

We use data on cohort state-level incidence of demand for transplants of different organs calculated based on administrative data provided by Organ Procurement and Transplantation Network (National UNOS STAR file) collected for the period 1990 till mid-2019[4]. OPTN data allows to analyze the demand for livers, kidneys, pancreas, hearts, lungs, any organs demanded.

[4] In this version of the working paper we only consider waitlist registration and transplantation period 2010-mid2019. In later versions we will analyze the 2000s and 1990s.

Table C.1 and Table C.2 demonstrate the timing of state laws when the minimum legal drinking age was lowered to below 21 during the early 1970s and increased back to 21 in the late 1970s and 1980s for distilled spirits (Table C.1) and any type of alcohol (Table C.2). The timing of lowering and increasing the minimum legal drinking age is from Wagenaar (1981), O'Malley and Wagenaar (1991), and Britannica ProCon.org.

If we consider minimal legal drinking age for any type of alcohol (see Table A1.1), 5 states had minimum legal drinking age for distilled spirits below 21 by the beginning of 1970, and 22 states have lowered the minimum legal drinking age of distilled spirits to below 21 years between 1970 and 1975. Then, these 27 states have raised their minimum legal drinking age for distilled spirits to 21 years between 1978 and 1988. There were 24 states which did not lower the drinking age for distilled spirits.

If we consider minimal legal drinking age for any type of alcohol (see Table A1.2), then 17 states had the drinking age below 21 at the beginning of 1970, and 23 states lowered their drinking age to below 21 during the 1970s. There were only 12 states who did not lower their MLDA for any type of alcohol.

In exploring the effect of minimum legal drinking age effect on demand for organs, we control for several characteristics which varied for different birth cohorts within a state. Such characteristics included per capita income, unemployment, per capita public medical aid, the percentage of adults who were high school graduates[5]. We collected that data from different sources. Per capita income and public medical aid figures are from the United States Bureau of Economic Analysis. Data for state population is taken from the Census of 2010 and the percentage of high school graduates is taken from the American Community Survey of 2010. Data on unemployment comes from the Bureau of Labor Statistics.

[5]Education variable is omitted from this analysis since we do not have enough observations for that version of the variable. We are going to include another version of that variable which has enough observations in next drafts.

3.4 Identification Strategy

We are applying event study methodology for the identification of the causal effect of MLDA on organ transplants. The first approach is a state and cohort fixed effects regression. The following equation represents this approach:

$$Y_{cs} = a_c + a_s + \sum_{k=-5, k\neq -1}^{10} b_k 1(c - e_s = k)_{cs} + dX_c + u_{cs}, \tag{1}$$

where Y_{cs} is the proportion of registered on the transplant waiting list in a specified period in a state s and belonging to cohort c divided by the number of people living in state s and belonging to cohort c, es is the birth year of the earliest cohort affected by the increase in the MLDA in a state s. $1(c - e_s = k)$ are the indicators for leads or lags of cohorts relative to treatment. The last cohort unaffected by the MLDA increase is omitted and is considered the base cohort. Cohort and state fixed effects are included in all specifications. X_{sc} is a vector of state time-variant characteristics. We include in X_{sc} the following control variables:per capita medical funding by states, unemployment, per capita personal income, the share of high school graduates for population age 25 and older. We expect to see $b_1 < 0$, reflecting a negative impact of increasing the minimum drinking age on the demand for organ transplants.

The key assumption for this approach to be valid is that without the policy change, the demand for organ transplants of different cohorts in different states should trend similarly. Model described by equation 1 allows to provide an evidence if that assumption is consistent with the data.

As a preliminary step, we are compiling an individual-level dataset where each row represents an individual on the waiting list. We consider 2010- mid-2019 as the period of registration. In the future work we plan to analyze also registration periods of 1990s and 2000s. Then, we aggregate data to the state-cohort level by calculating the number of people on the waiting list of a certain year of birth (cohort) and living in a certain state. For each cohort, we created a dummy variable indicating whether the individuals belonging to that cohort had legal access to alcohol when she/he was 18-20 years old.

Interstate migration is a potential threat to our approach. However, according to https://www.northamerican.com/infographics/where-they-grew-up, approximately 70-80% of Americans live in the same state where they were in their adolescence.

3.5 Results

3.5.1 Effects of the MLDA21 for Spirits on the Transplant Demand

States had different timeframes for adopting MLDA21 for different categories of alcoholic beverages: spirits, wine, and beer. In general, state governments were more willing to maintain a low MLDA for beer, so some states adopted the MLDA21 for spirits and extended that policy to other beverages. Our hypothesis is that spirits might be most harmful, and exposure to spirits at a young age more likely causes addiction. Therefore, we will examine the MLDA21 for spirits and for all alcoholic beverages separately.

We examine the effects of increasing the MLDA to 21 on the demand for transplants by estimating the equation 1 using the sample of 26 states adopting the MLDA21 between 1978 and 1988. The dependent variable is the number of people demanding for any organ transplants in the 100,000 population of the state-cohort cells. Limiting the sample to the ever-treated states identifies the effects of the law using the timing of the law's passage, and allows us to compare the outcomes among states that are arguably more similar than the always-treated states. The last cohort experiencing the non-MLDA21 was omitted in the model.

Estimates are displayed in Table C.3 Columns (1) and (2) and demonstrated in Figure C.1 and Figure C.2. Prior to the policy change, we find little evidence of differential trends. For $k<0$, all treatment coefficients are small in magnitude and never reach statistical significance, even at the 10 percent level. This provides evidence to support our assumption that without the MLDA21 policies, the trends of demand for transplants would have been similar across states.

In contrast, the demand for organ transplants decreases significantly following the MLDA21. The number of transplants demanded per 100,000 people declines by 86 cases by ten years after the policy was enacted. To place the treatment estimates in context, the mean demand was 151 per

100,000 in the year prior to treatment. The point estimates of the key coefficients are remarkably similar in magnitude and significance between the specifications with and without covariates. The effects gradually increase in the magnitude when the cohort is further out from policy enaction.

A number of factors may explain for the pattern of the effects. First, the MLDA21 can decrease youth's exposure to spirits directly. When adolescents are not eligible to buy spirits until they reach the age of 21, the probability of being addicted to alcohol may substantially decrease. Second, the MLDA21 may also lead to fewer drinking peers and forms the perception that drinking is harmful. It is also possible that the legislation enforcement was strengthened over the years (Toomey, Rosenfeld, and Wagenaar 1996).

Figures C.3-C.6 show the results for demand for individual organs: livers, kidneys, lungs, and hearts. The patterns are consistent for most organs, except for hearts: the coefficients in the pre-policy periods are small while the coefficients in the post-policy periods are larger, negative, and statistically significant.

3.5.2 Effects of the MLDA21 for Alcohol on the Transplant Demand

We run analogous models for the policy that increases the MLDA for any type of alcohol to 21 years old. The estimated effects on the demand for any organs are reported in Table C.1 Columns (3) and (4) and Figure C.2. Again, the coefficients are small and insignificant in the periods prior to the policy change, indicating parallel trends in the pre-policy period, supporting our research design. We can also see that the coefficients are robust to the addition of covariates. The effects of the MLDA21 for alcohol on demand for individual organs are presented in Figures A5-8.

The pattern observed in Figure C.2, and Figures C.7 - C.10 are similar to the graphs that present the effects of the MLDA21 for spirit but are less pronounced. This is also consistent with our expectation since exposure to wine and beer is arguably less harmful and addictive than spirits.

3.6 Conclusion

Organ failures are among the leading causes to deaths and the most expensive medical procedures in the United States. Medical literature has established the association between alcoholism and chronic dysfunction of organ systems. This paper provides the first causal evidence of the long-term impacts of increasing the MLDA to 21 in various states in the 1970s-1980s on reducing organ failures. By delaying exposure to alcoholic beverages, the MLDA 21 likely limits adolescents' exposure to alcohol and reduce the likelihood of alcoholism in adulthood and thus the risk of alcohol-related diseases, including organ failures.

We find that cohorts exposed to higher MLDA (21) had lower probability of having organ failures in later life. The empirical findings show that limited access to spirits and alcohol before the age of 21 reduced the demand for transplants by 86 and 50 per 100,000 population, respectively, after ten years, given that the average transplants demanded by the cohort prior to treatment is approximately 155.

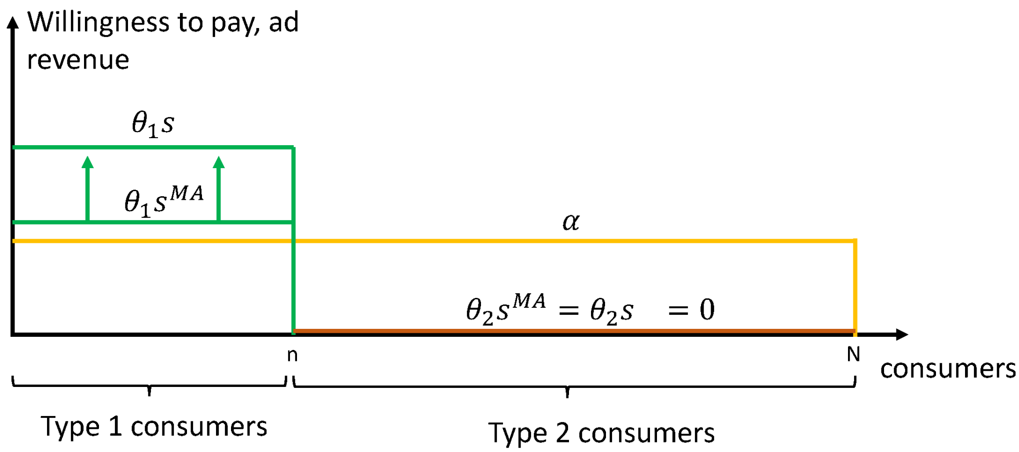
These findings have important implications for evaluating the benefits of the MLDA21 legislation. Besides preventing traffic fatalities, the MLDA21 has significantly reduced organ failures in adulthood, therefore might have increased productivity and life quality of the generations who were growing up in the presence of this legislation.

APPENDICES

APPENDIX A

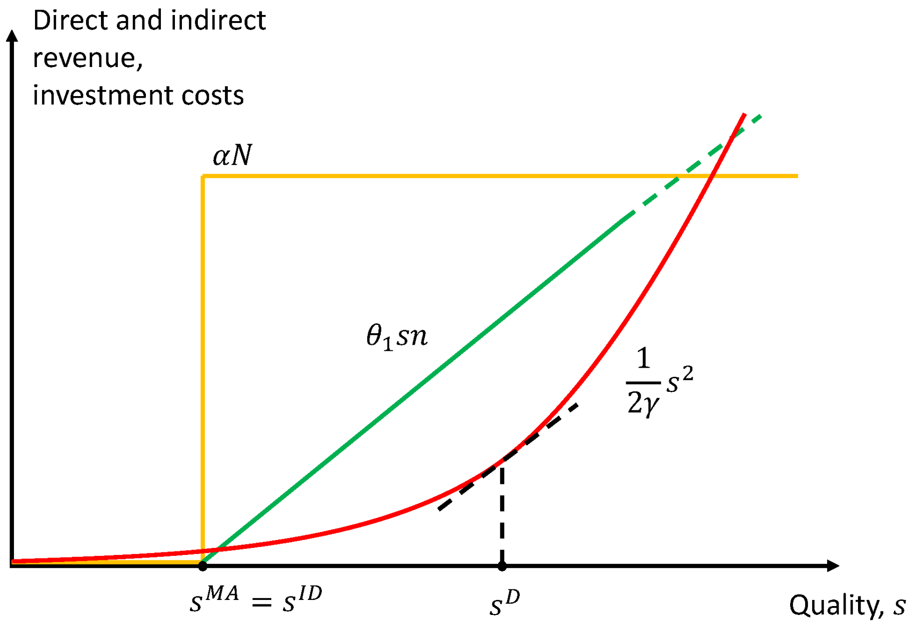
FIGURES FOR CHAPTER 1

Figure A.1: Willingness to Pay Of Two Types of Consumers for Different Levels of Search Engine Quality and Advertising Profits per Consumer



Note: This graph represents willingness to pay of type 1 (in green) and type 2 (in brown) consumers for a search engine of minimally acceptable quality s^{MA} vs a higher than minimally acceptable quality $s > s^{MA}$. Also it shows advertising profit (in yellow) that each type of consumer brings to the search engine. This graph illustrates that despite the fact that type 1 consumers are willing to pay for quality improvement, indirectly financed search engine may prefer not to improve the quality above minimally acceptable by consumers level, s^{MA}.

Figure A.2: Optimal Choice of Search Engine Quality Under Indirect vs Direct Model of Search Engine Financing

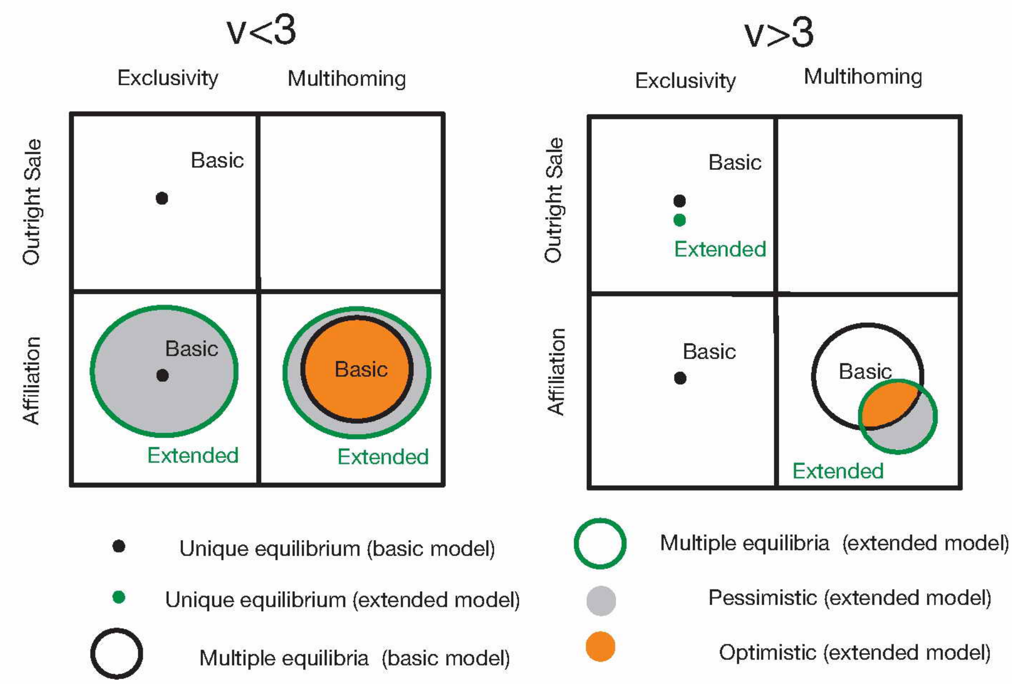


Note: This figure illustrates such parameter values of preferences and technologies when an indirect search engine will produce just minimally acceptable quality for consumers, s^{MA}, while direct search engine would produce higher quality search engine $s^D > s^{ID} = s^{MA}$.

APPENDIX B

FIGURES AND DERIVATIONS FOR CHAPTER 2

Figure B.1: Comparison of Equilibria in Basic (Exogenous Control) Versus Extended Model (Endogenous Control)



Note: Circles represent multiple equilibria, dots - unique equilibrium. Black color corresponds to basic model, green color - extended.

Table B.1: Second Stage Industry Profit Under Outright Sale (Homogenous Content Valuation)

	Second stage industry profit
multihoming	1
exclusivity for A against B	$J\left\{1+\left(\frac{v}{3}\right)^2, v-1\right\}$

Table B.2: Second Stage Industry Profit Under Affiliation (Homogenous Content Valuation)

	Second stage industry profit
multihoming	$1 + v$
exclusivity for A against B	$1 + \frac{v}{2}$

B.1 Derivations

Lemma 1. *Under outright sale control regime if total surplus from a piece of content is strictly decreasing in content price, then it is always optimal for platforms to set content price equal to the marginal cost (zero). If total surplus from a piece of content is independent of content price, then each platform cares only about the sum of platform access and content prices and chooses this sum to maximize its profits.*

$$\Pi_A = \max_{P_A, p_A} \{D_A \cdot (P_A + N_A \pi(p_A))\}$$

$$D_A = \begin{cases} 0 & ,\text{if } \frac{1}{2} + \frac{N_A s(p_A) - N_B s(p_B) - P_A + P_B}{2t} < 0 \\ \widehat{\theta} & ,\text{if } 0 < \frac{1}{2} + \frac{N_A s(p_A) - N_B s(p_B) - P_A + P_B}{2t} < 1 \\ 1 & ,\text{if } \frac{1}{2} + \frac{N_A s(p_A) - N_B s(p_B) - P_A + P_B}{2t} > 1 \end{cases}$$

$$D_B = 1 - D_A$$

Consider interior solution (no tipping)

$$\Pi_A = \underset{P_A, p_A}{Max} \left\{ \left(\frac{1}{2} + \frac{N_A s(p_A) - N_B s(p_B) - P_A + P_B}{2t} \right) \cdot (P_A + N_A \pi(p_A)) \right\}$$

Denote

$$\widetilde{P}_A \equiv P_A + N_A \pi(p_A); \widetilde{P}_B \equiv P_B + N_B \pi(p_B) \tag{B.1}$$

Then

$$\Pi_A = \max_{\widetilde{P}_A, p_A} \left\{ \left(\frac{1}{2} + \frac{N_A \left(s\left(p_A\right) + \pi\left(p_A\right)\right) - N_B \left(s\left(p_B\right) + \pi\left(p_B\right)\right) - \widetilde{P}_A + \widetilde{P}_B}{2t} \right) \cdot \widetilde{P}_A \right\}$$

Denote

$$w\left(p_A\right) = s\left(p_A\right) + \pi\left(p_A\right); w\left(p_B\right) = s\left(p_B\right) + \pi\left(p_B\right)$$

as the total surplus from a piece of content. Then

$$\Pi_A = \max_{\widetilde{P}_A, p_A} \left\{ \left(\frac{1}{2} + \frac{N_A w\left(p_A\right) - N_B w\left(p_B\right) - \widetilde{P}_A + \widetilde{P}_B}{2t} \right) \cdot \widetilde{P}_A \right\}$$

$FOC\left(\widetilde{P}_A\right)$:

$$\left(-\frac{1}{2t}\right) \cdot \widetilde{P}_A + \left(\frac{1}{2} + \frac{N_A w\left(p_A\right) - N_B w\left(p_B\right) - \widetilde{P}_A + \widetilde{P}_B}{2t} \right) \cdot 1 = 0,$$

or

$$\widetilde{P}_A = \frac{t}{2} + \frac{N_A w\left(p_A\right) - N_B w\left(p_B\right) + \widetilde{P}_B}{2} \tag{B.2}$$

$FOC\left(p_A\right)$:

$$\frac{N_A w'\left(p_A\right)}{2t} \cdot \widetilde{P}_A \leq 0 \text{ and } = 0 \text{ if } p_A > 0 \tag{B.3}$$

Therefore, if $w'\left(p_A\right) < 0$, then we get a corner solution $p_A = 0$ and $\widetilde{P}_A \equiv P_A$ according to B.2 and B.1. If $w'\left(p_A\right) = 0$, then p_A and P_A can take any value such that B.2 and B.1 are satisfied.

Derivation of platforms' second stage profits under outright sale

Outright sale

Case 1 (no consumers tipping in favor of A)

First, let us consider interior solution ($D_A \in (0, 1)$) or no tipping. As was shown in the Lemma 1 under outright sale in general platforms will choose content prices socially efficiently equal to marginal costs (zero) and get zero profits from any piece of content ($\pi(0) = 0$). Thus

$$D_A = \frac{1}{2} + \frac{N_A s(0) - N_B s(0) + P_B - P_A}{2t}$$

and

$$\Pi_A = \max_{P_A} \{P_A D_A\}$$

$FOC(P_A)$:

$$\frac{1}{2} + \frac{N_A s(0) - N_B s(0) + P_B - P_A}{2t} + P_A \left(\frac{-1}{2t}\right) = 0$$

or

$$P_A = \frac{t + N_A s(0) - N_B s(0) + P_B}{2}$$

By analogy, for platform B's $FOC(P_B)$:

$$P_B = \frac{t + N_B s(0) - N_A s(0) + P_A}{2}$$

Solving FOCs gives:

$$P_A = t + \frac{N_A s(0) - N_B s(0)}{3}$$

$$P_B = t + \frac{N_B w(0) - N_A w(0)}{3}$$

Substituting into demand gives

$$D_A = \frac{1}{2} + \frac{N_A s(0) - N_B s(0)}{6t}$$

Substituting demand and obtained optimal price into expression for profit gives

$$\Pi_A = \frac{1}{2t}\left(t + \frac{N_A s(0) - N_B s(0)}{3}\right)^2$$

or

$$\Pi_P(\Delta N) = \frac{\left(t + \frac{\Delta N s(0)}{3}\right)^2}{2t}$$

Hence, substituting parameter values considered in the text ($N = 1, t = 1$) and consumer surplus value for homogenous content preferences $s(0) = v$ obtain

$$\Pi_P(\Delta N) = \frac{\left(1 + \frac{\Delta N v}{3}\right)^2}{2}$$

For $\Delta N = 0$ (content multihoming)

$$\Pi_P(0) = \frac{1}{2}$$

For $\Delta N = 1$ (content exclusivity with the platform)

$$\Pi_P(1) = \frac{\left(1 + \frac{v}{3}\right)^2}{2}$$

For $\Delta N = -1$ (content exclusivity with the rival platform)

$$\Pi_P(1) = \frac{\left(1 - \frac{v}{3}\right)^2}{2}$$

And the demand for platform A is

$$D_A = \frac{1}{2} + \frac{\Delta N v}{6}$$

From this formula it is seen that under multihoming ($\Delta N = 0$) consumer tipping is impossible

$$D_A = \frac{1}{2}$$

Under exclusive outright sale ($\Delta N = 1$)

$$D_A = \frac{1}{2} + \frac{v}{6}$$

Thus consumer tipping in favor of platform A ($D_A = 1$) is only possible under exclusive outright sale case for

$$v > 3$$

Case 2 (exclusive outright sale consumers tipping in favor of A)

In case of consumer tipping to A ($D_A = 1$) A's profit is

$$\Pi_A = \max\{P_A D_A\} = \max\{P_A \cdot 1\}$$

Under competitive tipping it should be true that the following incentive compatibility condition for consumers is always satisfied

$$u_A(\theta = 1) \geq u_B(\theta = 1)$$

or

$$V + s(0) - t - P_A \geq V - P_B$$

As platform will make this constraint always binding (otherwise, it could always increase its price a bit and still attract all consumers and, thus, increase its profits) this condition will hold as equality and imply

$$P_A = s(0) - t + P_B$$

As by assumption there are no marginal costs of producing platforms the only possible equilibrium[1] (a la Bertrand because of competitive tipping) is

[1] Suppose not, $P_B > 0$, then B could always undercut its price and attract all consumers given that $s(0) - t + P_B = P_A$ and earn a positive profit.

$$P_A = s(0) - t, P_B = 0$$

Substituting obtained price into profit function gives.

For $\Delta N = 1$ (content exclusivity with the platform)

$$\Pi_P(1) = s(0) - t$$

For $\Delta N = -1$ (content exclusivity with the rival platform)

$$\Pi_P(-1) = 0$$

Hence, substituting parameter values considered in the text ($N = 1, t = 1$) and consumer surplus value for homogenous content preferences $s(0) = v$ obtain

$$\Pi_P(1) = v - 1$$

$$\Pi_P(-1) = 0$$

Combining case 1 and case 2 expressions above for platform profits we obtain expressions for profits used in the text.

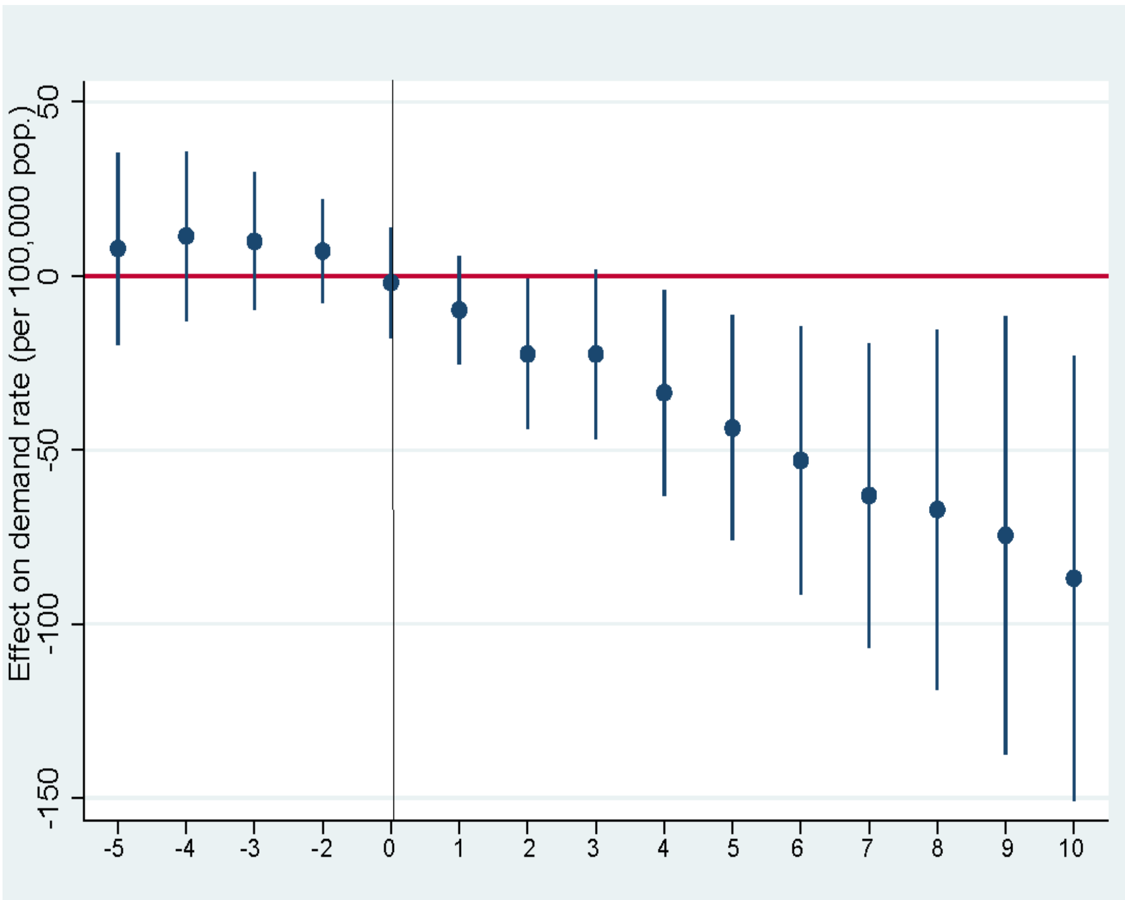
Affiliation

Under affiliation content providers maximize content profits and get $\pi\left(p^C\right)$ per piece of content, and consumers get $s\left(p^C\right)$ per piece of content. All above derived conditions for outright sale are the same for affiliation, but instead of term $s(0)$ term $s\left(p^C\right)$ should be used. Under homogenous content valuation $s\left(p^C\right) = 0$. This gives us expressions for platforms' profits under affiliation used in the text.

APPENDIX C

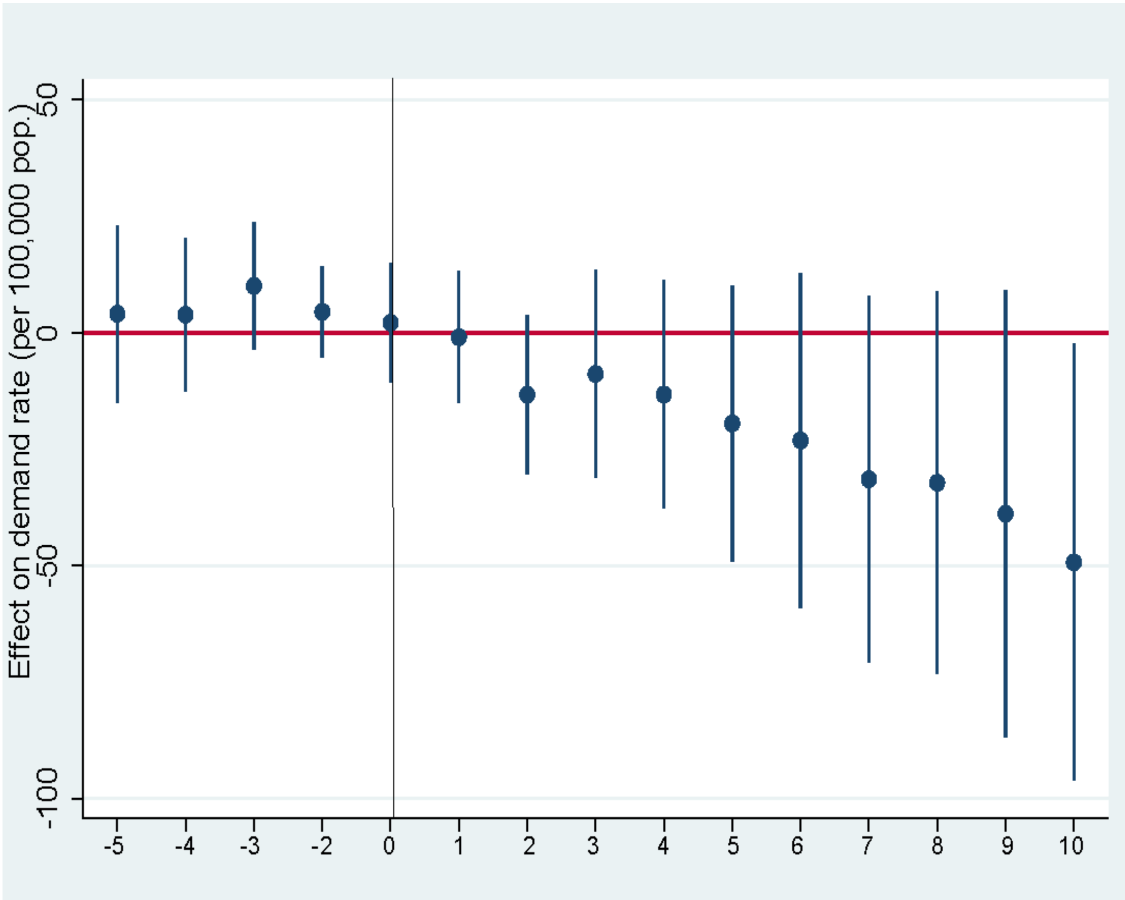
FIGURES AND TABLES FOR CHAPTER 3

Figure C.1: Effect of Increasing MLDA for Spirits on Demand for Any Organs



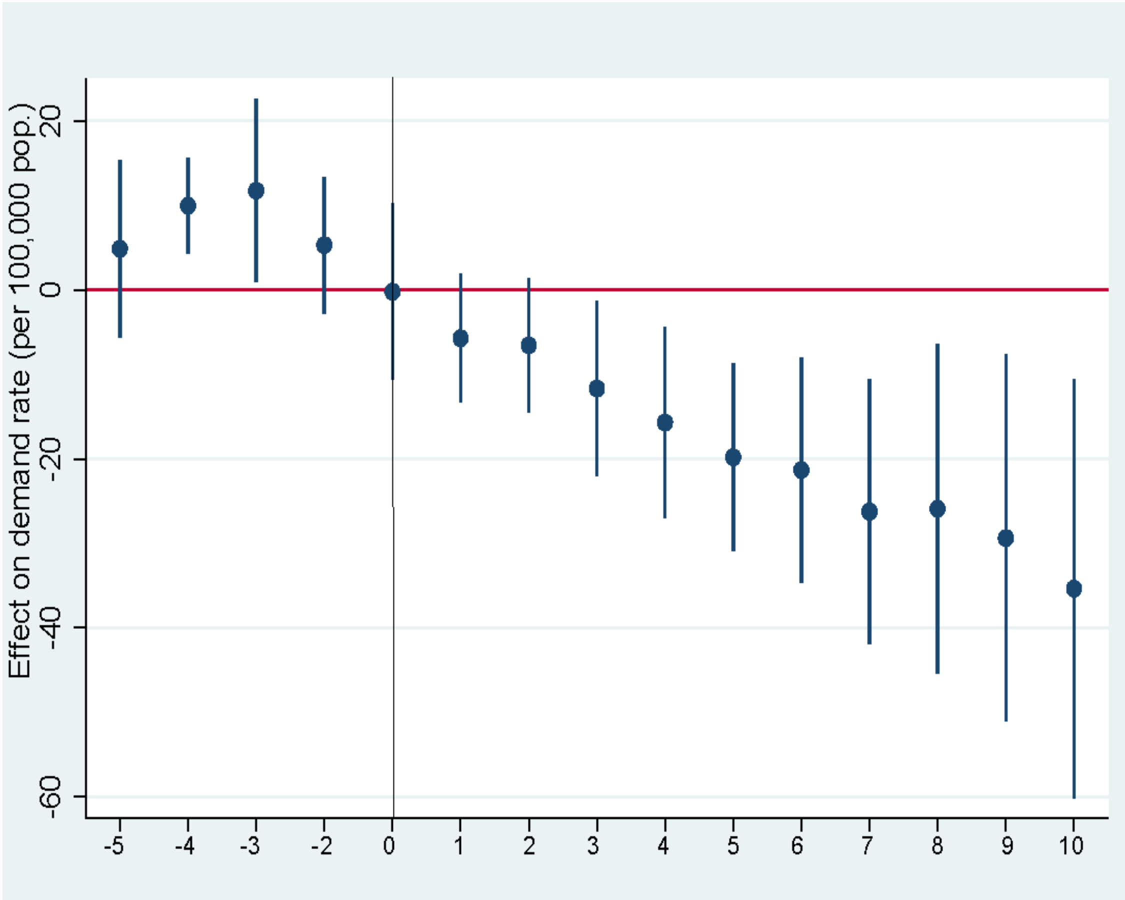
Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for any organs per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.2: Effect of Increasing MLDA for Any Alcohol on Demand for Any Organs



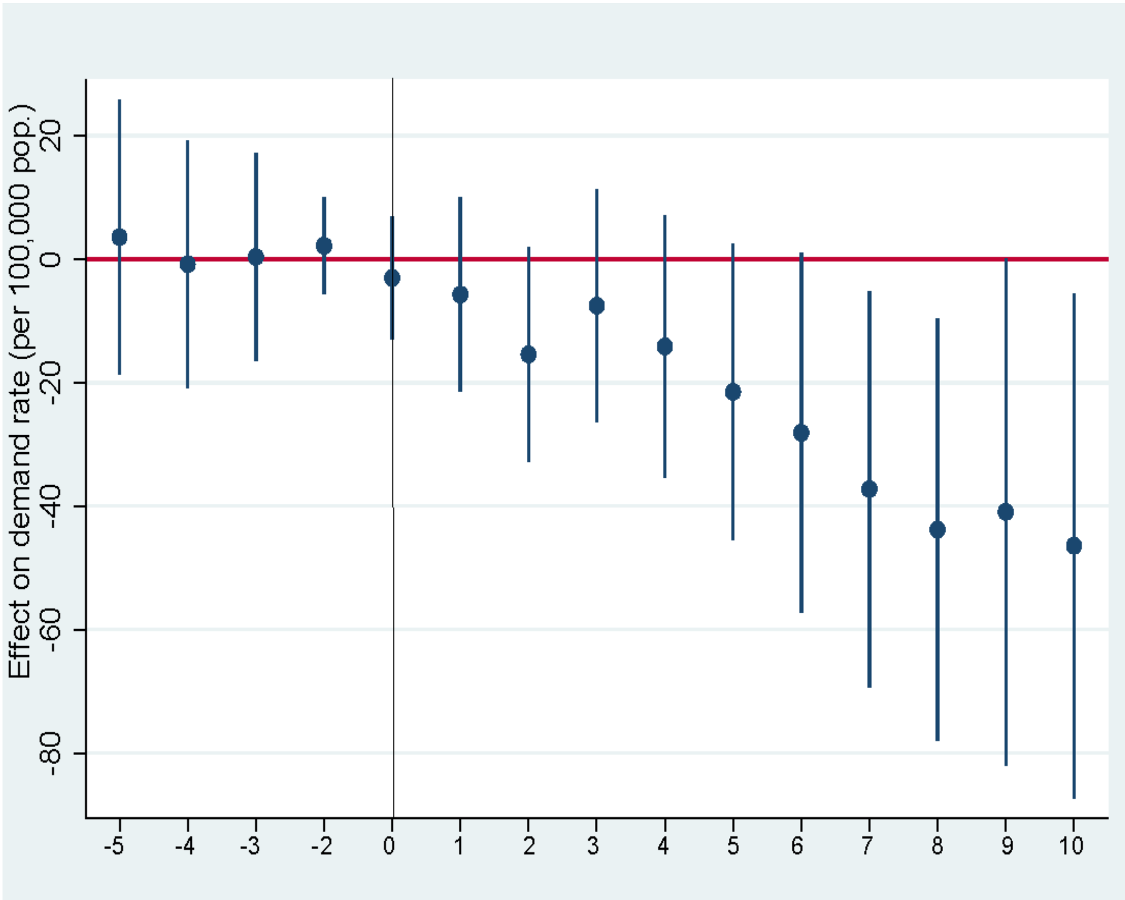
Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for any organs per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.3: Effect of Increasing MLDA for Spirits on Demand for Livers



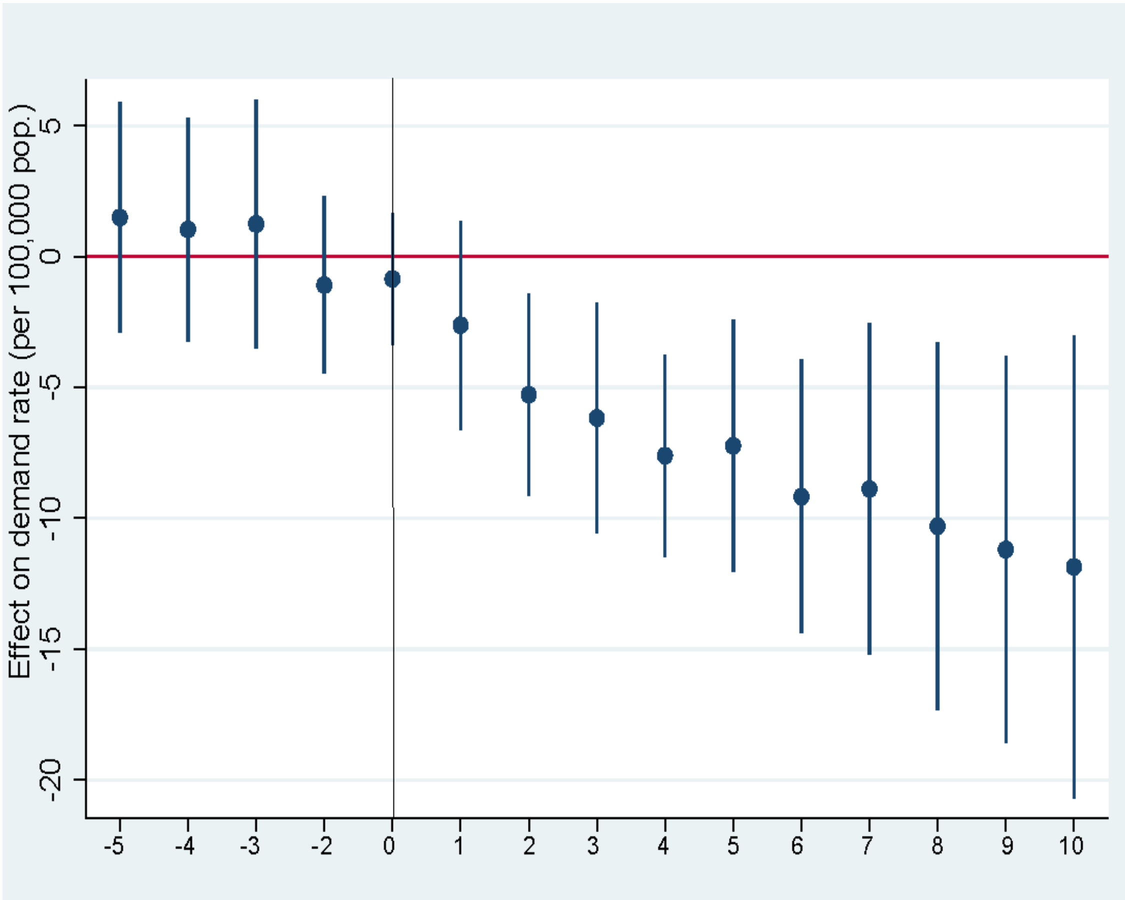
Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for livers per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.4: Effect of Increasing MLDA for Spirits on Demand for Kidneys



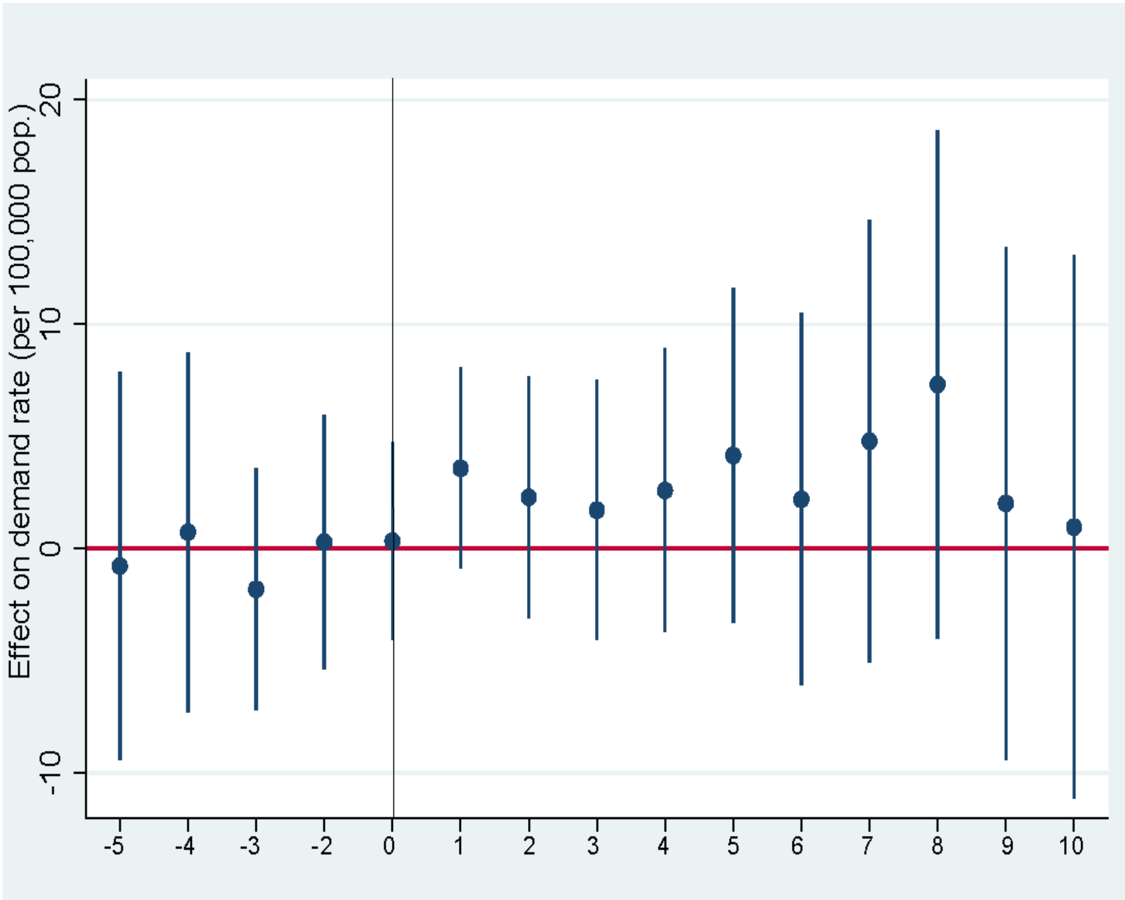
Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for kidneys per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.5: Effect of Increasing MLDA for Spirits on Demand for Lungs



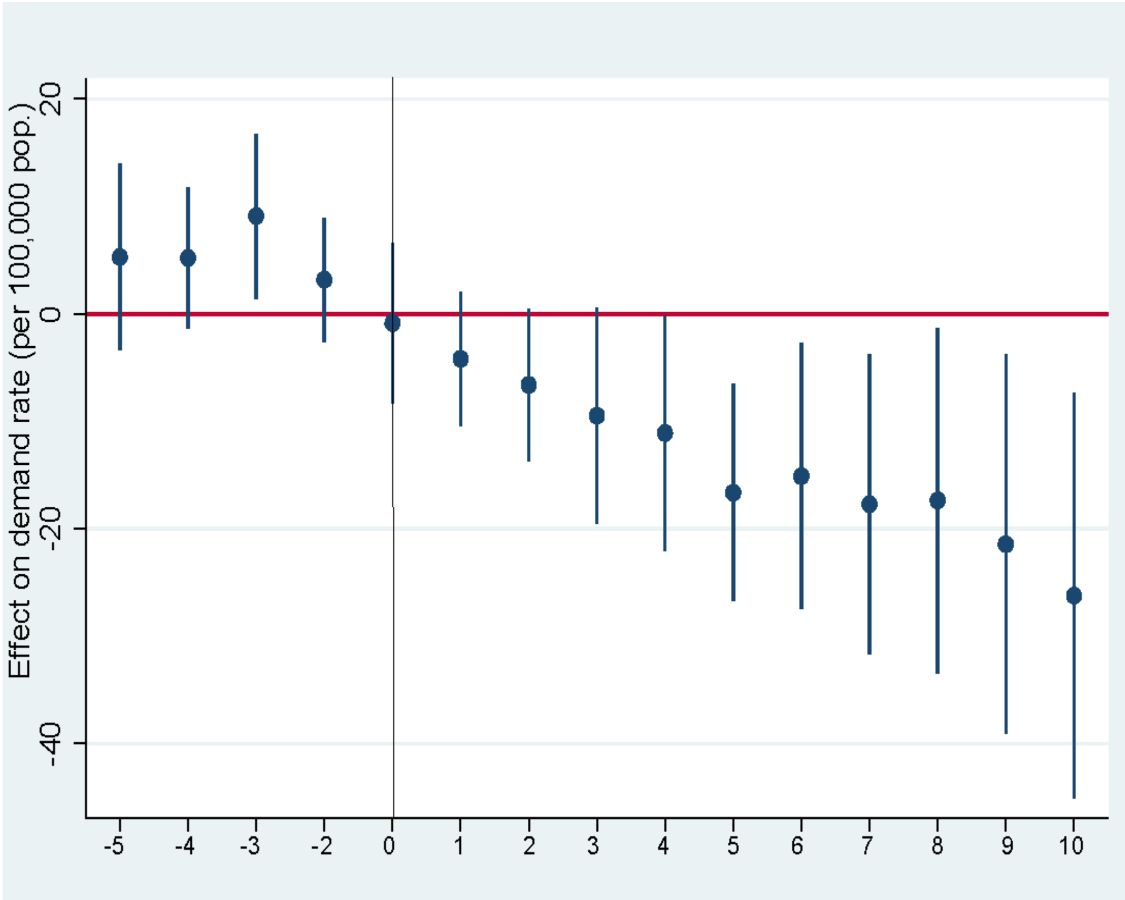
Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for lungs per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.6: Effect of Increasing MLDA for Spirits on Demand for Hearts



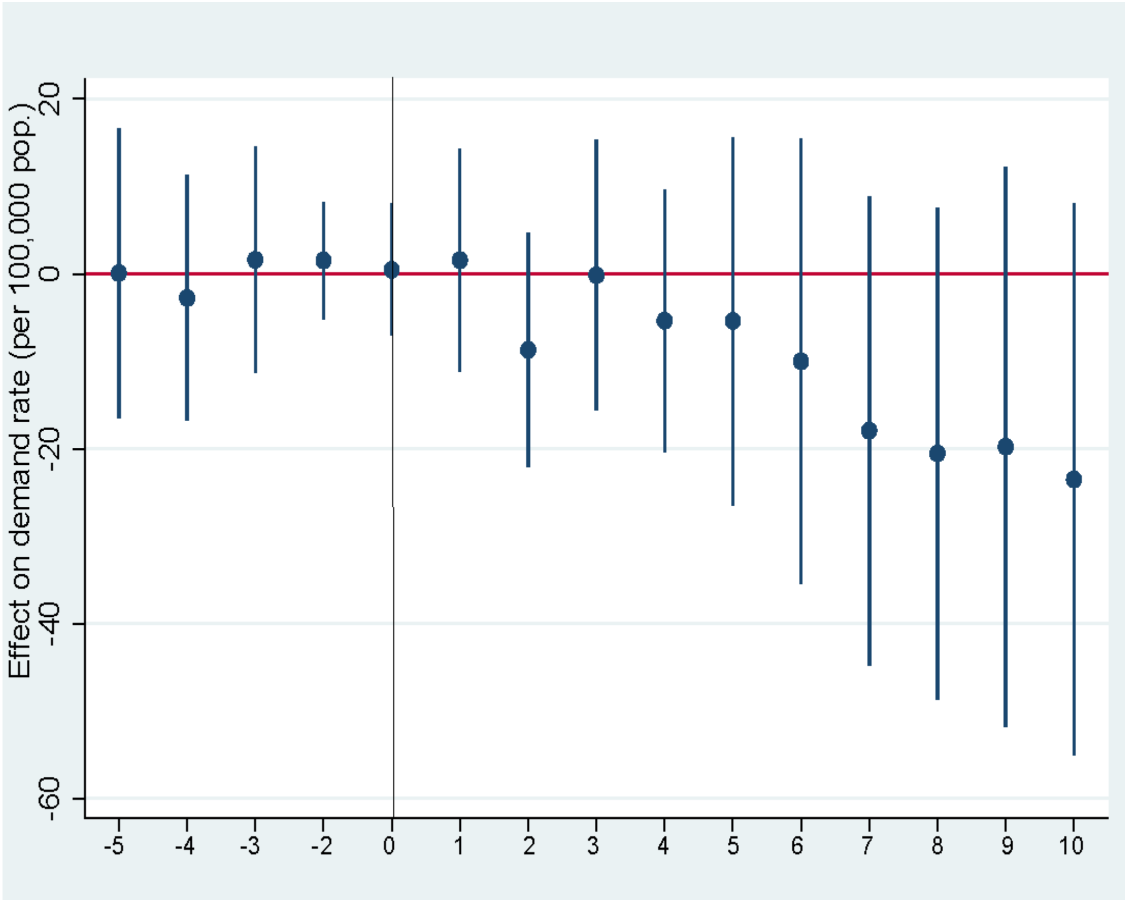
Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for hearts per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.7: Effect of Increasing MLDA for Any Alcohol on Demand for Livers



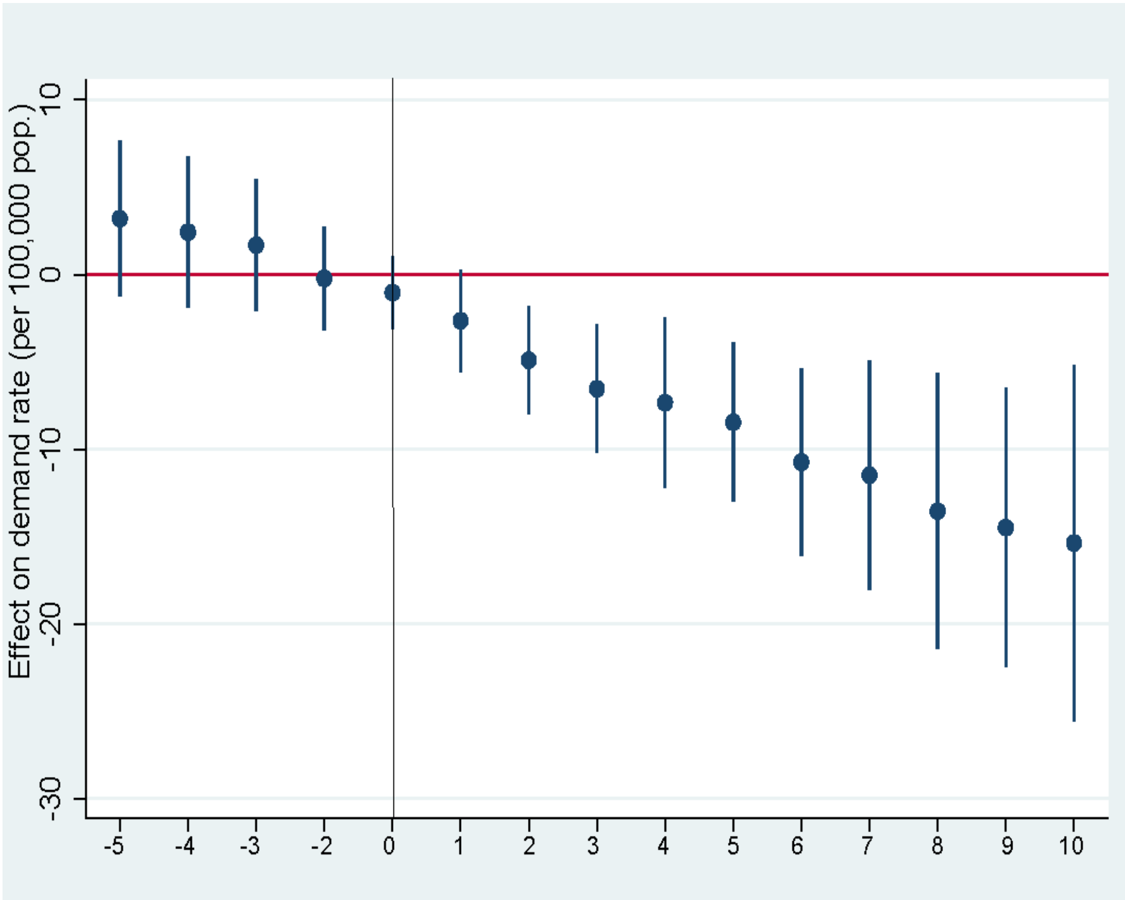
Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for livers per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.8: Effect of Increasing MLDA for Any Alcohol on Demand for Kidneys



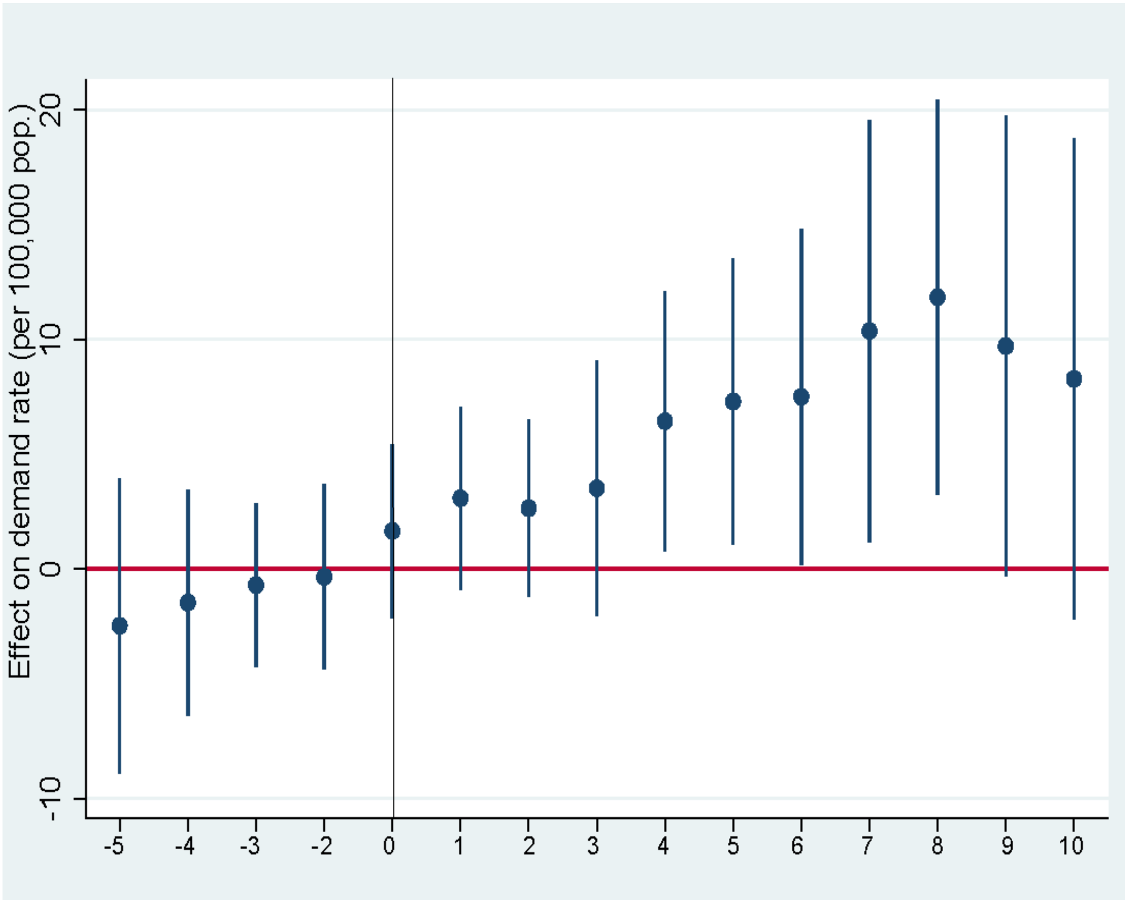
Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for kidneys per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.9: Effect of Increasing MLDA for Any Alcohol on Demand for Lungs



Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for lungs per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Figure C.10: Effect of Increasing MLDA for Any Alcohol on Demand for Hearts



Note: this figure plots the balanced event-study estimates of the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for hearts per 100000 population of that cohort. The coefficient in cohort (-1), the coefficient for last cohort not affected by the policy is normalized to zero (and omitted). Control variables include: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Standard errors are clustered at state level.

Table C.1: Timing Of Lowering the Minimum Legal Drinking Age Below and Raising to 21 Years for Distilled Spirits During 1970s and 1980s

Years	States lowering MLDA for distilled spirits below 21 during 1970s	States raising MLDA for distilled spirits to 21 during 1980s
prior to 1970	HI, LA, ME, NE, NY	
1970	AK	
1971	MT, TN, VT	
1972	AZ, CT, DE, GA, IA, ID, MI, RI, WV, WI	
1973	FL, MA, MN, NH, NJ, TX, WY	
1974		
1975	AL	
1978		MI
1980		
1982		
1983		NJ
1984		AK, DE, RI, TN
1985		AL, AZ, CT, FL, MA, ME, NE, NH, NY
1986		GA, HI, IA, MN, TX, VT, WI, WV
1987		ID, LA*, MT
1988		WY
1995		LA*
States with MLDA=21 for 1970s and 1980s	AR, CA, CO, DC, IL, IN, KS, KY, MD, MO, MS, NC, ND, NM, NV, OH, OK, OR, PA, SC, SD, UT, VA, WA.	

Note: the timing of lowering and increasing minimum legal drinking age is from Wagenaar (1981), O'Malley and Wagenaar (1991), and ProCon.org (2016). * Although de jure Louisiana has increased the minimum legal drinking age to 21 in 1987, due to a loophole, youth of age below 21 could get access to alcohol, and de facto increase of minimum legal drinking age happened in 1995, see Bragg (1996). ** Oklahoma (OK) according to DISCUS (1959-1972) all beverages were 21 except for 3.2 beer -18 for female off-sale, 32 on-sale, Male - 21. In 1976 MLDA because 18 for both males and females.

Table C.2: Timing Of Lowering the Minimum Legal Drinking Age Below and Raising to 21 Years for Any Type of Alcohol During 1970s and 1980s

Years	States lowering MLDA for at least some type of alcohol below 21 during 1970s	States raising MLDA for all types of alcohol to 21 during 1980s
prior to 1970	CO, DC, HI, ID, KS, LA, ME, MS, NC, NE, NY, OH, OK**, SC, SD, WI, WV	
1970	AK	
1971	MT, TN, VT	
1972	AZ, CT, DE, GA, IA, MI, RI	
1973	FL, IL, MA, MN, NH, NJ, TX, WY	
1974	MD, VA	
1975	AL	
1978		MI
1980		IL
1982		MD
1983		NJ, OK
1984		AK, DE, RI, TN
1985		AL, AZ, CO, CT, FL, KS, MA, ME, NE, NH, NY, VA
1986		DC, GA, HI, IA, MN, MS, NC, SC, TX, VT, WI, WV
1987		ID, LA*, MT, OH
1988		SD, WY
1995		LA*
States with MLDA=21 for 1970s and 1980s	AR, CA, IN, KY, MO, ND, NM, NV, OR, PA, UT, WA	

Note: the timing of lowering and increasing minimum legal drinking age is from Wagenaar (1981), O'Malley and Wagenaar (1991), and ProCon.org (2016). * Although de jure Louisiana has increased the minimum legal drinking age to 21 in 1987, due to a loophole, youth of age below 21 could get access to alcohol, and de facto increase of minimum legal drinking age happened in 1995, see Bragg (1996). ** Oklahoma (OK) according to DISCUS (1959-1972) all beverages were 21 except for 3.2 beer -18 for female off-sale, 32 on-sale, Male - 21. In 1976 MLDA because 18 for both males and females.

Table C.3: Estimated Effects of MLDA 21 for Spirits and Alcohol on Demand for Transplants

	MLDA21 for Spirits		MLDA21 for Alcohol	
VARIABLES	no controls	with controls	no controls	with controls
5 years pre-policy	7.363	7.892	12.430*	4.089
	(8.847)	(13.401)	(7.028)	(9.365)
4 years pre-policy	11.730	11.502	10.670	3.865
	(9.991)	(11.802)	(7.548)	(8.061)
3 years pre-policy	10.576	9.940	14.657**	10.050
	(8.106)	(9.579)	(6.530)	(6.704)
2 years pre-policy	7.887	7.163	7.005	4.492
	(6.381)	(7.142)	(4.738)	(4.830)
1 year pre-policy				
Year the MLDA 21 took effect	-3.372	-1.907	-1.063	2.152
	(7.245)	(7.656)	(6.103)	(6.267)
1 year post-policy	-13.287**	-9.777	-7.430	-0.966
	(6.107)	(7.529)	(5.677)	(6.958)
2 year post-policy	-27.144***	-22.447**	-22.527***	-13.288
	(8.506)	(10.409)	(6.957)	(8.409)
3 year post-policy	-27.711**	-22.436*	-20.739**	-8.833
	(10.700)	(11.764)	(9.085)	(10.954)
4 year post-policy	-39.860***	-33.577**	-28.107***	-13.256
	(8.596)	(14.286)	(8.792)	(12.083)
5 year post-policy	-51.160***	-43.699***	-37.510***	-19.498
	(9.329)	(15.670)	(11.040)	(14.603)
6 year post-policy	-61.619***	-53.002***	-44.025***	-23.142
	(9.212)	(18.626)	(12.577)	(17.726)
7 year post-policy	-73.255***	-63.087***	-55.401***	-31.465
	(9.824)	(21.166)	(13.552)	(19.395)
8 year post-policy	-78.636***	-67.147**	-58.989***	-32.210
	(9.516)	(25.031)	(13.176)	(20.251)
9 year post-policy	-87.645***	-74.542**	-69.134***	-38.848
	(11.464)	(30.543)	(14.259)	(23.670)
10 year post-policy	-102.006***	-86.845***	-83.885***	-49.292**
	(8.730)	(31.066)	(13.251)	(23.122)
Observations	416	416	592	592
R-squared	0.797	0.802	0.799	0.806

Note: this table shows the impacts of the MLDA policy increase. The dependent variable is the cohort's demand for any organs per 100000 population of that cohort. The coefficient in cohort (-1) is the reference cohort and omitted. Control variables: per capita income, unemployment rate, share of high school graduates for population of age 25 and older, per capita medical aid, share of black population. These estimates are taken from a balanced event study sample where we retained only 5 cohorts before first affected cohort by policy and 10 cohorts after. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at state level.

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