THREE CHAPTERS IN INDUSTRIAL ORGANIZATION

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Contents

Introduction

We live in a consumer society. Countless firms are competing over our attention and wallets. The firms' strategic decision making is not only crucial to their survival, it also affects the well-being of consumers. Understanding market structures and firm behavior is therefore essential to manage firm performance and regulate the business environment. Over time, industries change and new insight is required. The purpose of this thesis is to shed light on current topics related to trade in digital and physical goods (wholesale and retail).

First of all, these are important industries because they occupy a considerable proportion of consumers' time and money. Consider, for instance, grocery retail. In pre-covid times, the average Norwegian household went grocery shopping 3.4 times per week, spending more than 11 percent of its income (Alfnes et al.; 2019, Vegard; 2018). In the choice of which store to visit, factors like store location, design, assortment and prices play an important role. Since retail prices depend on input prices, both supplier and retail decisions may have a big impact on consumer welfare.[1]

When people are not grocery shopping, it is not unlikely that they consume media content. While many traditional media are losing ground, digital media thrive. For instance, 60 percent of the Norwegian population read online newspapers on a daily basis (Statistics Norway, 2021a). In contrast, only 24 percent read print newspapers. Although digital media consumption may not account for the largest share of household budgets, it is eating a remarkable number of hours. On average, Norwegians spend almost 3 hours on digital mass media every day (Statistics Norway, 2021b). The same tendency applies

[1]When it comes to grocery retail, physical stores still account for the vast majority of sales (Kitch, 2019). Hence, we do not elaborate on the fact that some factors would be more important (e.g home delivery) or less important (e.g. store location) for online stores.

worldwide: internet users dedicate about 2.5 hours a day just to social media (Tankovska, 2021). Clearly, the behavior of digital platforms is affecting us.

All three chapters analyze firm behavior, aiming to broaden current knowledge of firms' strategic decision making. However, each chapter concentrates on a different set of research questions. To answer them, we use both economic theory and econometric techniques. While the first and third chapter are purely theoretical contributions, we combine theory with an empirical approach in the second chapter. In the following, I provide a short summary for each of the three chapters.

The first chapter is a joint work with Atle Haugen. We analyze how recent developments in the media industry impact platform performance and market equilibria. First, we pay attention to how digitalization facilitates consumption of several media platforms and improves the platforms ability to target advertisements. For instance, while reading an additional print newspaper might require a shopping trip, reading more online news only requires a few extra clicks. Second, we consider the increased strategic importance of first-party data due to greater privacy demand and market regulation. Limited access to third-party data pushes the platforms to use first-party data. However, such internally collected data provides exclusive consumer information, which might give the platforms a competitive advantage. We derive a theoretical model where platforms exploit first-party data to target ads. With targeting technologies, the platforms can use collected data to learn more about their subscribers and thereby display more relevant ads. Other things equal, this increases both advertisers' willingness to pay and platform profits. But suppose that the technology performs better the more data that is fed to the algorithm. Then, targeting may increase the importance of attracting consumers and lead to fierce price competition that harms the platforms. We show that this is indeed the outcome, unless consumers subscribe to more than one platform (i.e multi-home). In the latter case, competition over consumers is not a zero-sum game and the use of targeting technologies could benefit both consumers and platforms. Despite outcomes being completely different, the scenario where consumers subscribe to more than one platforms is often overlooked. Existing literature typically make the assumption that consumers only use one platform (i.e single-home). Interestingly, we find that this may not be an equilibrium outcome. This is an important result, because it means that existing literature might be misleading. A key takeaway from this paper is thus that awareness regarding the implications of assuming single-homing or multi-homing is crucial when evaluating the impact of targeting.

The second chapter is co-written with Frode Steen and Simen A. Ulsaker. Motivated by recent changes in the retail landscape, we analyze how the rise of discount variety retail has changed the competition towards grocery stores.[2] The trend where variety discounters add groceries to their product range implies that grocery retailers and variety discounters have a partly overlapping assortment.[3] Hence, they compete in some product categories, but not in others. This adds some complexity to store location choices. While there is a trend in retail towards co-location, it is not obvious that a grocery store would benefit from having a variety store next door. On one side, more consumers are attracted to a location with both store types. This creates a positive demand effect. On the other side, fiercer competition over overlapping products gives rise to a negative demand effect. To gain more insight, we measure how entries and relocations of the Norwegian variety discount chain Europris affect local grocery stores' sales and traffic. Benefiting from a rich data set including travelling distances between the stores and local grocery store activity, we use a diff-in-diff approach to estimate the effect. We find that store establishments have a significant impact on local grocery stores sales and traffic. Interestingly, our results suggest that the impact has an S-shaped relationship with the distance between the stores: when Europris entries are sufficiently close, it attracts so many consumers to the market that local grocery sales and traffic increase. But when the new Europris stores are too far away to be reached from the same parking, the competitive effect is stronger and makes the grocery stores worse off. When the distance increases even further, the entry effect gradually approaches zero. Our findings show that existing literature, which tend to treat local competition as a linear effect, may not tell the entire story. We also demonstrate that the empirical outcomes can be carried over to a theoretical framework.

The third chapter is a joint work with Øystein Foros, Atle Haugen and Hans Jarle Kind. Here we focus on price setting by dominant suppliers, aiming to shed light on why they price discriminate and to better understand in what situations it would be a better strategy to commit to uniform pricing. We consider a market with one supplier and two retailers,

[2] Discount variety retail refers to stores selling general merchandise such as pet supplies, household essentials, electronics, furniture and toys at an affordable price. An example of this retail format is the US dollar stores.

[3] Another contributing factor to the assortment overlap is that grocery retailers offer non-food items such as household essentials, pet supplies and health care products.

and assume that the retailers may invest in a substitute to the supplier's product. By doing so, the retailers can strengthen their position towards the supplier and obtain more favorable input prices. We show that if one retailer is larger than the other, it has stronger incentives to invest and may therefore obtain a selective rebate. This is what we refer to as size-based input price discrimination. But suppose that the supplier instead commits to uniform pricing. Then, the large retailer's investment reduces its wholesale price, but unfortunately for the large retailer and the supplier, it also reduces the wholesale price of the smaller retailer by the same amount. First, all else equal, the supplier would be worse off from the commitment. It would have preferred ex-post to charge a higher input price to the smaller retailer. So, how could the supplier possibly benefit from charging both retailers the same input price? We show that this has to do with how the commitment affect the large retailer's investment incentives. Since investments do not provide a price advantage under uniform pricing, the large retailer invests less. Hence, the supplier faces a trade-off between reducing downstream investment incentives and the ability to charge a higher price from the smallest retailer. We find that the greater downstream competition, the more likely that the supplier will commit to uniform pricing. This has to do with retailers investing more the fiercer they compete, because the relative input price matters more. To reduce the downward pressure on input price, the supplier can charge a uniform price. We show that this can be a profitable strategy for the supplier if the competitive pressure is sufficiently strong. It is also worth mentioning that if the supplier benefits from uniform pricing, consumers are typically worse off, and vice versa. This insight could have important policy implications.

This thesis does not provide answers to all the questions out there. On the bright side, this means that there are things left for future research to explore. Let me point out some weaknesses of current research and areas that would benefit from further investigation. In the first chapter we do not assess whether the increased use of first-party data and targeting technologies change the way firms collaborate with each other. More research is required to find out if it makes firms more inclined to cooperate, for instance by forming data-sharing alliances. Another question that deserves greater attention is to what extent consumers actually want targeted ads. On one side, it could increase the relevance of the displayed ads. But on the other side, it also raises privacy concerns. Currently, the literature is inconclusive on this issue. Nonetheless, it is highly relevant from a welfare perspective.

In the second chapter, we measure how establishment of discount variety stores affect local grocery stores. Since we focus on a particular discount grocery chain, we cannot extrapolate the findings to other grocery concepts like corner shops or supermarkets. For instance, consumers that primarily shop at supermarkets (and not discount grocery stores) could have less elastic demand and be less responsive to discount variety establishments. A natural extension would therefore be to include more grocery store formats in the analysis. Moreover, we only consider the effect of establishment on aggregated demand. Future studies could use individual-level data to identify underlying factors that determine how individual consumers respond.

In the third chapter, we assume that retailers may invest in a substitute to the supplier's product (e.g. a private label) prior to receiving an offer from the supplier. Other papers, like Katz (1987), suppose that investments take place afterwards, and only in case the retailer rejects the supplier's offer. In reality, the timing of investments is probably not as black and white: Consider a retailer that invests in a private label. To have a credible threat, an upfront investment might be necessary. Suppose then that the retailer rejects the supplier's offer and actually wants to produce its own brand. This would most likely require some marketing of the private label, illustrating the need for additional investments. A suggestion for future research is to extend the model to allow for several investment stages. Furthermore, the retailers in our model invest in an alternative source of supply that they might end up not using. The assumption that the retailers only sell the supplier's brand or a private label could be too strict in some situations. In grocery stores, for instance, one often finds both private labels and national brands. In a next phase, the model could enable retailers to offer a combination of private labels and the supplier's product. Finally, I want to mention our brief analysis of how a large retailer can strategically over- or underinvest to induce exit or prevent entry of a smaller rival. A more thorough examination of entry/exit would be useful and could potentially be a paper on its own. Considering that current research on this topic is incomplete, additional studies are in demand.

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Chapter 1

The impact of targeting technologies and consumer multi-homing on digital platform competiton

The impact of targeting technologies and consumer multi-homing on digital platform competition[*]

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Abstract

In this paper, we address how targeting and consumer multi-homing impact platform competition and market equilibria in two-sided markets. We analyze platforms that are financed by both advertising and subscription fees, and let them adopt a targeting technology with increasing performance in audience size: a larger audience generates more consumer data, which improves the platforms' targeting ability and allows them to extract more ad revenues. Targeting therefore increases the importance of attracting consumers. Previous literature has shown that this could result in fierce price competition if consumers subscribe to only one platform (i.e. single-home). Surprisingly, we find that pure single-homing possibly does not constitute a Nash equilibrium. Instead, platforms might rationally set prices that induce consumers to subscribe to more than one platform (i.e. multi-home). With multi-homing, a platform's audience size is not restricted by the number of subscribers on rival platforms. Hence, multi-homing softens the competition over consumers. We show that this might imply that equilibrium profit is higher with than without targeting, in sharp contrast to what previous literature predicts.

Keywords: Two-sided markets, digital platforms, targeted advertising, incremental pricing, consumer multi-homing.

JEL classifications: D11, D21, L13, L82.

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1.1 Introduction

Media platforms compete for consumer attention. While some consumers are devoted to a single media provider, others spread their attention across multiple platforms.[1] The emergence of digital technologies has facilitated the latter, which we refer to as consumer multi-homing. All it takes to read an additional newspaper online, is a few extra clicks. In contrast, to access more print news, one has to go out and buy another newspaper.[2]

For ad-financed platforms, the distinction between exclusive (single-homing) and shared (multi-homing) consumers is utterly important. Having exclusive access to certain consumers implies that advertisers cannot reach them elsewhere, allowing the platforms to price their ad space accordingly. Consumers that are shared with other platforms, on the other hand, are typically worth less in the ad market. Since the advertisers can reach these consumers on other platforms as well, the platforms can only charge advertisers the incremental value of an additional impression. This is known as the incremental pricing principle (see e.g., Ambrus *et al.*, 2016; Athey *et al.*, 2018 and Anderson *et al.*, 2018).

In the digital era, platforms increasingly adopt advanced advertising technologies such as targeting. This can help identify the consumers that are most likely to buy the advertisers' product and make sure that impressions are directed towards the most promising candidates. Our model incorporates a targeting technology with increasing returns to scale in the audience size. One could, for instance, think of a machine-learning algorithm that improves as it is exposed to more consumer data. Platforms that collect more user data could therefore be better able to connect advertisers with the target audience. The upshot is that advertisers might be willing to pay more per impression on platforms with a large audience and higher targeting ability.[3]

Previous studies have shown that targeting might increase competition and benefit consumers through lower subscription prices (see e.g. Kox *et al.*, 2017; Crampes *et al.*, 2009).[4] Moreover, the studies emphasize that the additional revenues from the ad side of

[1] This has caught the attention of a number of researchers, such as Ambrus *et al.* (2016), Athey *et al.* (2018), Anderson *et al.* (2017; 2018; 2019).

[2] Gentzkow and Shapiro (2011) and Affeldt *et al.* (2019) argue why digital technologies make multi-homing more compelling.

[3] Goettler (2012) studies broadcast networks and provides empirical evidence that the ad price per viewer might increase in audience size.

[4] Kox *et al.* (2017) explicitly examine targeting, while Crampes *et al.* (2009) consider a more general advertising technology.

the market tend to get competed away on the consumer side of the market, leaving the platforms worse off. Kox *et al.* (2017) also point out that even though it would be in the platforms' common interest not to target ads, each platform might have individual incentives to do so. These findings are, however, based on the assumption that consumers single-home (join a single platform). Despite the relevance to modern media markets, the literature that combines consumer multi-homing and targeting is scarce. The purpose of this paper is to enrich the theoretical understanding of this phenomenon.

We scrutinize the outcomes under both single-homing and multi-homing, and investigate whether they constitute Nash equilibria. In line with existing literature, we find that targeting generates a prisoner's dilemma situation under the assumption of single-homing. But remarkably, we find that platforms may not want to set subscription prices that makes consumers prefer single-homing. Indeed, setting prices that incentivize consumers to multi-home could be a unique equilibrium. Combining elements from Crampes *et al.* (2009), Ambrus *et al.* (2016) and Anderson *et al.* (2017), we show that things turn out quite differently if consumers multi-home. In the absence of targeting, consumer multi-homing makes subscription prices strategically independent: if one platform changes its price, this has no impact on rival platforms' optimal price setting. To put it more concretely: suppose that you are going to purchase The Washington Post and consider to buy a copy of The New York Times (NYT) as well. When deciding whether to purchase NYT as an additional newspaper, what matters is the price of NYT (and not The Post).

This does not change if we introduce targeting. However, in that case, the platforms must take into account that the price setting of rival platforms will affect the profitability of targeting. If we revert to our previous example: By reducing its subscription price, The NYT could improve its targeting ability and charge advertisers extra. Since advertisers are not willing to pay the full extra for shared consumers (recall the incremental pricing principle), this would be more attractive the larger the number of exclusive consumers. A price reduction by The Post would, however, increase the number of consumers that buy The Post in addition to NYT. The NYT's gain from increased targeting ability would therefore be counteracted by a greater fraction of shared consumers. Hence, targeting has surprising consequences. In contrast to what is usually observed, subscription prices become strategic substitutes: it is less profitable for a platform to reduce its subscription price if rival platforms do the same.

Although targeting still makes it optimal to reduce subscription prices when consumers multi-home, it does not trigger an aggressive response from rival platforms. As a result, it is more imperative to implement targeting. Yet, softer competition alone cannot ensure that targeting is profitable. We show that this can only be guaranteed if multi-homing consumers are sufficiently valuable to advertisers.

Outline. The paper proceeds as follows. In section 1.2, we review related literature. In sections 1.3 and 1.4, we present a basic model and introduce a targeting technology. In section 1.5, we compare our results to disclose when targeting is profitable, and in section 1.6, we investigate potential equilibria. We conclude in section 1.7.

1.2 Related literature

This paper draws on two strands of media literature that are not usually brought together. One strand investigates the importance of consumer multi-homing, and the other examines the impact of targeted advertising.

Athey and Gans (2010) and Bergemann and Bonatti (2011) were among the first to address the impact of targeting on media platform competition. The former paper considers competition between a local platform that is tailored to the local audience (which is the local advertiser's intended audience) and a general platform that depends on targeting technologies to identify the advertiser's relevant consumer base. Targeting helps the general platform allocate constrained ad space more efficiently and allows it to accommodate a larger number of advertisers.

Bergemann and Bonatti (2011) model competition between online and offline media under the assumption that online media has higher targeting ability. Absent targeting, each advertiser places ads on several platforms to ensure that it reaches enough consumers. In this model, consumers' interests are correlated with their presence on a specific platform. Increased targeting ability thus allows advertisers to concentrate on just the most relevant platforms, reducing the overall demand for ads.

More recently, Gong *et al.* (2019) propose a different approach in which competition for consumers plays a prominent role. In their model, differences in the platforms' ability to target ads are exogenously given.[5] Assuming that consumers dislike irrelevant ads, Gong *et al.* suggest that improved targeting reduces the consumers' nuisance costs. At the same time, greater targeting ability attracts more advertisers. Hence, platforms with superior targeting abilities attract more consumers and advertisers, and they are more profitable.

A common feature of these papers is that platform differences are exogenously given. This gives rise to significant effects on the supply and demand of ads, which would be less prominent in a model with symmetric platforms (like ours). We disregard the allocative effects, and allow targeting ability to be determined within the model: by reducing its subscription price, a platform can increase its audience size and improve its targeting ability. Since none of the mentioned papers regards subscription fees, a similar interplay between the two sides of the market does not occur in these papers. This is one explanation of why we arrive at quite different results. Another reason is that we use a different targeting technology. As demonstrated by Crampes *et al.* (2009), the nature of the advertising technology is decisive for platform behavior and market outcomes.

Regarding the targeting specification, we find the contribution by Hagiu and Wright (2020) interesting. The paper pays attention to how technologies may improve based on learning from consumer data. This insight is useful for the understanding of how learning-based targeting technologies function. A general form of our targeting specification can be recognized in Crampes *et al.* (2009), who model the impact of advertising technologies with constant, decreasing and increasing returns to scale in the audience size, and point at the limitation of assuming linearity. Although the authors do not accentuate increasing returns to scale, we argue that the current focus on first-party data and technology makes this particular specification highly relevant. We therefore use a variant of this technology in our set-up. Like most previous research on targeting and media platform competition, Crampes *et al.* (2009) assume consumer single-homing. We relax this assumption, and show that this provides entirely different outcomes.

The use of consumer data to target ads has raised privacy concerns. Johnson (2013) stresses that targeting might be harmful when consumers value privacy. He investigates the impact of targeting when consumers have access to ad-avoidance tools, and shows that consumers tend to block too few ads in equilibrium. Kox *et al.* (2017) incorporate privacy

[5] In an extension, Gong *et al.* (2019) allow the platforms to invest in targeting ability, and show that under-investment is most likely to occur.

considerations in a work that is closer to ours. In a similar framework, the authors show that targeting reduces consumer welfare if the disutility of sharing personal information is greater than the advantage of lower subscription prices. Recall from the Introduction that Kox *et al.* also find that platform profits decrease in targeting. As a result, their model suggests that stricter privacy regulations benefit both consumers and platforms. An important difference between Kox *et al.* (2017) and this paper is that the former assumes a linear advertising technology and consumer single-homing.

This paper adds to the growing literature that covers consumer multi-homing. A key take away from existing research is the incremental pricing principle that we describe in the Introduction. Ambrus *et al.* (2016) emphasize that an implication of advertisers' lower valuation of shared consumers is that it is not only the overall demand that counts; the *composition* of the demand also matters. When advertisers place ads on platforms with multi-homing consumers, there is a risk that some consumers have seen the ad before. As pointed out by Athey *et al.* (2018), impressing the same consumer twice is less efficient than impressing two different consumers. We combine this insight of ad-financed platform markets with elements from the user-financed platform market in Anderson *et al.* (2017) to derive a two-sided model with dual source financing.

Although various papers assess different aspects of consumer multi-homing, the literature that integrates multi-homing with targeted advertising is scarce. There are, however, a few exceptions. Taylor (2012) investigates how targeting affects platforms' incentives to improve content in order to increase their share of consumer attention. The paper focuses on how the platforms can retain consumer attention. In contrast, we disregard the attention span of the audience and rather focus on its size. Another exception is D'Annunzio and Russo (2020), who study the role of ad networks and how tracking technologies affect market outcomes. However, since they focus on a different part of the industry (ad networks), they address other and complementary questions.

1.3 The model

We consider two media platforms that offer subscriptions to consumers and advertising space (eyeballs) to advertisers. We employ a simple Hotelling (1929) model, with a line of length *one*, and assign one platform to each endpoint, i.e., platform 1 is located at

$x_1 = 0$ and platform 2 is located at $x_2 = 1$. Along the line, there is a unit mass of uniformly distributed consumers. The distribution represents the consumers' taste: the greater distance to a platform, the greater mismatch between the consumer preferences and the platform characteristics.

We consider two different regimes (which we later analyze whether constitute Nash equilibria). One of them is a pure single-homing regime (hereafter referred to as the single-homing regime) where all consumers subscribe to only one platform. The other is a multi-homing regime where some (but not all) consumers use more than one platform.[6] The outcomes for both regimes are presented.

1.3.1 Consumer demand

Single-homing consumers join only the platform they prefer the most. Let u_i represent the utility a consumer located at x obtains from subscribing to platform $i = 1, 2$:

$$u_i = v - t|x - x_i| - p_i. \tag{1.1}$$

The parameter $v > 0$ is the intrinsic utility of joining a platform, $t > 0$ represents the disutility of the mismatch between the consumer's preferences and the platform's characteristics, and p_i is the subscription price.

The consumer that is indifferent between only subscribing to platform 1 and only subscribing to platform 2 is located at $\widetilde{x}$, where $u_1 = u_2$. Consumers to the left of $\widetilde{x}$ subscribe to platform 1 and consumers to the right subscribe to platform 2. Hence, the demand function (superscript 'S' for single-homing regime) equals:

$$D_i^S = \frac{1}{2} + \frac{p_j - p_i}{2t}. \tag{1.2}$$

We do, however, allow consumers to subscribe to both platforms. The utility from dual subscription equals the sum of the individual utilities:

$$u_{1+2} = 2v - t - p_1 - p_2. \tag{1.3}$$

[6]With complete multi-homing, targeting would neither affect demand nor subscription prices. In this case, the analysis simply boils down to the change in ad prices.

If the incremental utility of multi-homing is positive for some consumers, $u_{1+2}(x) \geq u_i(x)$, those consumers will subscribe to both platforms. Hence, each platform potentially serves two groups of consumers: exclusive subscribers and subscribers who are shared with the rival platform.

Let x_{12} represent the location of the consumer who is indifferent between subscribing to just platform 1 and subscribing to both platform 1 and platform 2.[7] Since platform 2 does not provide any additional utility to the indifferent consumer, $u_{1+2} = u_1$. Platform 1's exclusive demand then arises from the consumers who are located to the left of x_{12}. It follows that the platforms' shared demand is made up by the consumers located between x_{12} and x_{21}. This is illustrated in Figure 1.1.

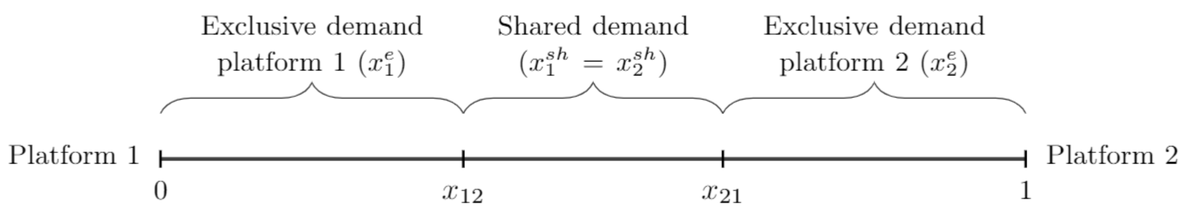

Figure 1.1: Demand platform $i = 1, 2$.

We solve $u_{1+2} = u_1$ and $u_{1+2} = u_2$ and find $x_{12} = \frac{1}{t}\left(-v + t + p_2\right)$ and $x_{21} = \frac{1}{t}(v - p_1)$, respectively. With symmetric platforms, we get that platform i's exclusive demand is given by

$$x_i^e = \frac{-v + t + p_j}{t}, \tag{1.4}$$

whereas its shared demand equals

$$x_i^{sh} = \frac{2v - t - p_i - p_j}{t}. \tag{1.5}$$

Total demand is the sum of exclusive demand and shared demand:

$$D_i^M = x_i^e + x_i^{sh} = \frac{v - p_i}{t}. \tag{1.6}$$

[7] Vice versa, x_{21} represents the location of the consumer that is indifferent between subscribing to only platform 2 and both platform 2 and platform 1.

Equation (1.6) tells us that total demand for platform i is independent of the rival platform's subscription price (p_j). A change in p_j will, however, affect the composition of platform i's demand. From equation (1.4), we see that the number of exclusive subscribers is increasing in p_j, while equation (1.5) shows an inverse relationship between the number of shared subscribers and p_j.

1.3.2 Advertisers and Platforms

Turning to the advertising side, we normalize the number of advertisers to *one*. The demand for ads is perfectly elastic, and we assume that each advertiser purchase space for one ad per platform. In line with the incremental pricing principle, we assume that the advertisers are willing to pay α_i to reach an exclusive consumer, but only a fraction $\sigma\alpha_i$ to reach a shared consumer, where $\sigma \in (0, 1)$.[8] It follows that platform i's ad revenue can be defined as

$$A_i^k = \alpha_i x_i^e + \sigma\alpha_i x_i^{sh}, \tag{1.7}$$

where superscripts $k = S$ and $k = M$ represent the single-homing regime and the multi-homing regime, respectively.

Total profit is given by[9]

$$\pi_i^k = p_i^k D_i^k + \alpha_i \left(x_i^e + \sigma x_i^{sh}\right). \tag{1.8}$$

Notice that if all consumers single-home, then $x_i^{mh} = 0$ and $x_i^e = D_i^S$.

1.3.3 No targeting

Consider first a model without targeting. In this situation, we assume that the advertiser value of reaching a consumer is not platform dependent, such that $\alpha_i = \alpha_j = \alpha$. We differentiate equation (1.8) and find the first-order condition

$$\frac{\partial \pi_i^k}{\partial p_i^k} = \left[D_i^k + \frac{\partial D_i^k}{\partial p_i^k} p_i^k\right] + \left[\alpha\left(\frac{\partial x_i^e}{\partial p_i^k} + \sigma\frac{\partial x_i^{sh}}{\partial p_i^k}\right)\right] = 0. \tag{1.9}$$

The first square bracket on the right-hand side of equation (1.9) deals with the consumer

[8]This corresponds to Anderson *et al.* (2018).

[9]We set all costs to zero to simplify the model.

side of the market, corresponding to a standard one-sided model. If we consider an increase in p_i, this implies that each consumer pays more, but it also means a lower number of subscribers. In our two-sided model, the price increase has an impact on the ad side of the market as well: platform i displays fewer ads and thereby loses ad revenues. This is captured by the second square bracket. Because of the negative effect a price increase has on ad revenues, the optimal subscription price is lower in a two-sided model.

Solving equation (1.9) for p_i^k gives the best-response functions:

$$p_i^M(p_j) = \frac{v - \sigma\alpha}{2} \text{ and } p_i^S(p_j) = \frac{t + p_j - \alpha}{2}. \tag{1.10}$$

We note that in the multi-homing regime, subscription prices are strategically independent.[10] In other words, platform i's subscription price is not responsive to changes in platform j's subscription price. To see why, suppose that platform j adjusts p_j. From section 1.3.1, we know that even though it alters the number of exclusive and shared consumers, the price change has no effect on platform i's total demand. This is because the location of platform i's marginal consumer stays the same. Keep in mind that the marginal consumer is located where her incremental value of subscribing to platform i is zero. Hence, platform i's subscription price still extracts the marginal consumer's incremental benefit. Besides, platform i's price setting does not affect the advertisers' valuation of the marginal consumer. Consequently, platform i has no incentive to change its subscription price in response to an adjustment in p_j. In the single-homing regime, we get the standard result that prices are strategic complements.

Lemma 1 *(No targeting) Subscription prices are*

(i) strategic complements in the single-homing regime

(ii) strategically independent in the multi-homing regime

1.4 Introducing targeting

Next, we introduce targeting to our model. We recognize that advertisers may not only care about the reach of ads, but also about the quality of the match with the audience. Suppose that the platforms implement targeting technologies that enable them to create

[10] This is in line with Anderson *et al.* (2017).

better matches between advertisers and viewers. Moreover, the technology becomes more accurate as the platforms increase their audience size and thereby generate more data.[11] We assume that advertisers are willing to pay for improvements in the platforms' targeting ability, and formulate the ad price as follows:

$$\alpha_i^k = \alpha(1 + \varphi D_i^k) \tag{1.11}$$

where φ is a dummy that takes on the value *one* when targeting is included in the model and *zero* otherwise. Notice that in the latter case, equation (1.11) reverts to the non-targeting ad price (α). For φ equal to *one*, the definition implies that the ad price is increasing in the platform's audience size ($\frac{\partial \alpha_i^k}{\partial D_i^k} > 0$), capturing the benefit of having more consumer data and improved targeting ability.

In the targeting model, α is interpreted as measurement of how efficiently the platforms are using consumer data to improve their targeting ability. As we proceed, we will see how this adjustment of the model can change the results drastically.

Inserting equation (1.11) into equation (1.8), and differentiating with respect to own price, we find the new first-order condition:

$$\frac{\partial \pi_i^k}{\partial p_i^k} = D_i^k + \frac{\partial D_i^k}{\partial p_i^k} p_i^k + \alpha(1 + \varphi D_i^k) \left(\frac{\partial x_i^e}{\partial p_i^k} + \sigma \frac{\partial x_i^{sh}}{\partial p_i^k} \right) + \varphi \frac{\partial \alpha_i^k}{\partial p_i^k} \left(x_i^e + \sigma x_i^{sh} \right) = 0. \tag{1.12}$$

When φ equals *zero*, we recognize equation (1.12) as the first-order condition in the model without targeting (cf. equation (1.9)). The two additional terms that appear when φ equals *one* represent the effects that emerge when we incorporate targeting. First, consider the third term on the right hand side. It tells us that ad revenues are more sensitive to changes in the number of ad impressions (in response to a change in the subscription price) than without targeting.[12] The explanation is that the ad price, which corresponds to the first part of the third term (cf. equation (1.11)), is higher with targeting ($\varphi = 1$). Second, we evaluate the fourth term. This expression captures a property that is not present in the model without targeting, namely that a platform's ad price responds to changes in its own

[11] We assume that each consumer delivers one data point, such that we measure the amount of data by the number of consumers.

[12] Since each consumer is impressed once, the number of subscribers is equivalent to the number of ad impressions.

subscription price. An increase in p_i^k causes a reduction in α_i^k, and vice versa.

Solving equation (1.12) for p_i^k , we find the best-response functions:

$$p_i^M(p_j) = \frac{v\,(t+\alpha) - \alpha\,(t+3v\sigma) - \alpha p_j\,(1-\sigma)}{2(t-\alpha\sigma)} \text{ and } p_i^S(p_j) = \frac{t\,(t-2\alpha) + p_j\,(t-\alpha)}{2t-\alpha}. \qquad (1.13)$$

The best-response functions reveal a striking difference between the single-homing regime and the multi-homing regime. If all consumers single-home, subscription prices are strategic complements ($dp_i^S/dp_j > 0$). In contrast, if at least some consumers multi-home, subscription prices are strategic substitutes ($dp_i^M/dp_j < 0$). This means that the optimal response to changes in the rival platform's subscription price depends on whether consumers only single-home or if some of them multi-home.

We can state:

Proposition 1 *(Targeting) When platforms target ads, subscription prices are*

(i) strategic complements in the single-homing regime

(ii) strategic substitutes in the multi-homing regime

The first result in Proposition 1 is well known in the literature: in a single-homing regime, the best response to a change in the rival subscription price is to adjust own price in the same direction.

The second result in Proposition 1, however, is quite surprising. While platform i's best response to a change in the rival subscription price is to do nothing in the multi-homing model without targeting (cf. Lemma 1), the best response in the targeting model is to adjust p_i^M in the opposite direction. Since targeting does not change the property of total demand being independent of the rival subscription price, the difference between the models may not be intuitive. After all, this property implies that p_i^M extracts the marginal consumer's incremental benefit regardless of any changes in p_j^M. The key to understanding why a change in p_j^M still induces a response, is that targeting enables platform i to affect the advertisers' willingness to pay. To see why, suppose that platform j increases p_j^M. This creates a shift from shared to exclusive subscribers for platform i, which implies a smaller share of discounted ad impressions. Platform i would therefore gain from increasing its ad price. Targeting enables the platform to do so by reducing p_i^M and improving its targeting ability. Conversely, a reduction in p_j^M provides incentives to increase p_i^M.

1.5 When is targeting profitable?

In this section, we compare the outcomes with and without targeting, and reveal when targeting is profitable. First, we find the symmetric non-targeting equilibrium prices. Solving the best-response functions in equation (1.10) simultaneously, we have

$$p^M = \frac{v - \sigma\alpha}{2} \text{ and } p^S = t - \alpha. \tag{1.14}$$

We then find the symmetric targeting equilibrium prices (the asterisk superscript denotes targeting) by solving the best-response functions in equation (1.13) simultaneously:

$$p^{M^*} = \frac{v\,(t+\alpha) - \alpha\,(t + 3v\sigma)}{2t + \alpha(1 - 3\sigma)} \text{ and } p^{S^*} = t - 2\alpha. \tag{1.15}$$

Comparing equations (1.14) and (1.15), we observe that subscription prices are lower when platforms target ads, irrespective of whether all consumers single-home or if some multi-home.

Targeting provides greater incentives to attract a larger audience, and to do so, the platforms lower their subscription prices.

We can state:

Lemma 2 *Subscription prices will be lower when platforms use targeting technologies.*

Proof. See Appendix. ■

In the following, we first analyze the single-homing regime, then proceed to the multi-homing regime.

1.5.1 Single-homing

We restrict our attention to markets with full coverage and endogenously non-negative prices. This, as well as fulfillment of the stability and second-order conditions, is ensured by Condition 1:

Condition 1 *(Single-homing)* $\frac{5}{2}\alpha < t < \frac{2}{3}(v + \alpha)$.

It follows from Lemma 2 and Proposition 1 that targeting leads to fiercer price competition.

The symmetric equilibrium demand is equivalent with and without targeting:

$$D^{S^*} = D^S = \frac{1}{2}. \tag{1.16}$$

It follows that subscription revenues are lower with targeting. Even though ad revenues are higher, they do not fully compensate for the lost subscription revenues. Inserting (1.16), (1.15) and (1.14) into (1.8), we find the equilibrium profits with and without targeting, respectively:

$$\pi^{S^*} = \frac{1}{4}(2t - \alpha) \text{ and } \pi^S = \frac{1}{2}t. \tag{1.17}$$

Equation (1.17) shows clearly that the targeting profit is lower than the non-targeting profit and decreasing in the technology's sensitivity to more data. The reason is that the higher α, the greater the incentive to reduce the subscription price, which significantly reduces subscription revenues. This raises the question of whether the platforms at all wish to adopt targeting technologies. Although it is in the platforms' common interest not to target, each platform has incentives to deviate from the mutually beneficial strategy. The platforms might therefore end up in a prisoner's dilemma situation where all platforms target (see also Kox *et al.*, 2017).

We state:

Lemma 3 *(Prisoner's dilemma) When all consumers single-home, targeting is a dominant strategy and the platforms end up in a prisoner's dilemma.*

Proof. See Appendix. ■

As we demonstrate in the equilibrium analysis, the platforms could, however, be better off by setting the multi-homing price and also attract consumers who already subscribe to the rival platform.

1.5.2 Multi-homing

Assume now consumer multi-homing. We consider partial multi-homing, i.e. situations where some, but not all, consumers use both platforms. Note that $t > \frac{1}{2}(v + 3\sigma\alpha)$ and $t < v + \sigma\alpha$ ensure the existence of exclusive and shared consumers, respectively. Moreover, we confine the analysis to situations with endogenously non-negative subscription prices and parameter values that satisfy all second-order and stability constraints. The conditions are given in the Appendix.

From Lemma 2 and Proposition 1 it follows that targeting provides incentives to reduce the subscription price, and that the rival platform will respond favorably. Moreover, the incentive to lower the price increases with advertisers' willingness to pay for shared consumers. This is captured in our model by the σ-parameter, where $\partial p^{M^*}/\partial \sigma < 0$. The price reduction contributes to greater overall demand, and the increase is reinforced by the rival platform's response. Nonetheless, we find that equilibrium subscription revenues are lower with targeting ($p^{M^*} D^{M^*} < p^M D^M$).

For targeting to be profitable, two conditions must therefore be satisfied: (i) Ad revenues must increase with targeting; and (ii) the increase in ad revenues must be greater than the loss in subscription revenues. Comparing ad revenues with and without targeting, we find that ad revenues are greater with targeting if $\sigma > \frac{1}{3}$. However, if $\sigma \leq \frac{1}{3}$, that is not necessarily true. The smaller σ, the lower is the ad price the platforms can charge for impressing shared consumers. This is particularly harmful in combination with weak platform preferences (low t), because targeting then creates a greater shift from exclusive consumers to shared consumers. A larger proportion of less valuable shared consumers could, in this case, offset the advantage of an increased ad price.

Finally, whether targeting is profitable or not thus depends on σ. We find it useful to consider $\sigma > \frac{1}{3}$ and $\sigma \leq \frac{1}{3}$ separately. The exact calculations are found in the Appendix.

First, we look at the case where $\sigma > \frac{1}{3}$. We find that $v > \alpha \left(\sigma + \sqrt{\sigma (\sigma + 1)} \right)$ is required to satisfy the multi-homing conditions. The more responsive the ad price is to the audience size (α) and the more advertisers value shared consumers (σ), the stronger incentives the platforms have to set lower subscription prices, and the greater must the intrinsic utility (v) be to ensure non-negative subscription prices.

As σ goes towards $\frac{1}{3}$, the minimum value of v is given by $v_{\min} = \alpha + \varepsilon$. By definition, $\sigma_{\min} = \frac{1}{3} + \varepsilon$. For both $v_{\min}$ and $\sigma_{\min}$, we have that targeting provides greater profits:

$$(\pi^{M^*} - \pi^M)|_{v_{\min}} > 0 \text{ and } (\pi^{M^*} - \pi^M)|_{\sigma_{\min}} > 0.$$

Moreover, we have that the difference between profits with and without targeting is increasing in σ evaluated at $v = v_{\min}$ ($\frac{d(\pi^{M^*} - \pi^M)}{d\sigma}|_{v_{\min}} > 0$), and the difference is increasing in v evaluated at $\sigma = \sigma_{\min}$ $(\frac{d(\pi^{M^*}-\pi^M)}{dv}|_{\sigma_{\min}} > 0)$. Finally, higher v-values enhance the increase in $(\pi^{M^*} - \pi^M)$ that follows from a higher σ:

$$\frac{d\left(\frac{d(\pi^{M^*}-\pi^M)}{d\sigma}\right)}{dv} > 0.$$

In sum, this means that targeting is profitable for all $\sigma > \frac{1}{3}$. We then consider $\sigma \leq \frac{1}{3}$. Because shared consumers have lower value in the ad market for small $\sigma-$values, the incentives to increase the audience size are weaker, and positive subscription prices can be achieved even for $v < \alpha$. For $\sigma \leq \frac{1}{3}$, targeting does not necessarily increase ad revenues. Since targeting also reduces subscription revenues, it might lead to lower profits.

We summarize the results in the following proposition:

Proposition 2 *(Multi-homing). Suppose that the multi-homing conditions hold. Targeting is profitable if advertisers place a high enough value on shared consumers. A sufficient condition is $\sigma > \frac{1}{3}$.*

Proof. See Appendix. ■

Combining Lemma 3 and Proposition 2, gives us the following corollary:

Corollary 1 *Targeting can only be profitable in the multi-homing regime*

1.6 Equilibrium analysis

We now proceed to comparing the market outcomes with pure single-homing and multi-homing and examining the existence of Nash equilibria. In this part, we restrict our attention to parameter values that fulfill the conditions for both the single-homing model and the multi-homing model. From Condition 1, we have that this requires that $v > \frac{11}{4}\alpha$. To illustrate the key point, we set $v = 3\alpha$, which is close to the minimum $v-$value. In the Robustness section in the Appendix, we show that the results we arrive at are valid also for $v > 3\alpha$, at least if shared consumers are not virtually worthless to advertisers.

Condition 2 ensures partial multi-homing in the multi-homing regime, non-negative prices and full market coverage in the single-homing regime, in addition to satisfying second-order and stability conditions.

Condition 2 *(Equilibrium)* $\max\{\frac{5}{2}\alpha,\ \frac{3}{2}\alpha\,(\sigma+1)\} < t < \frac{10}{3}\alpha.$

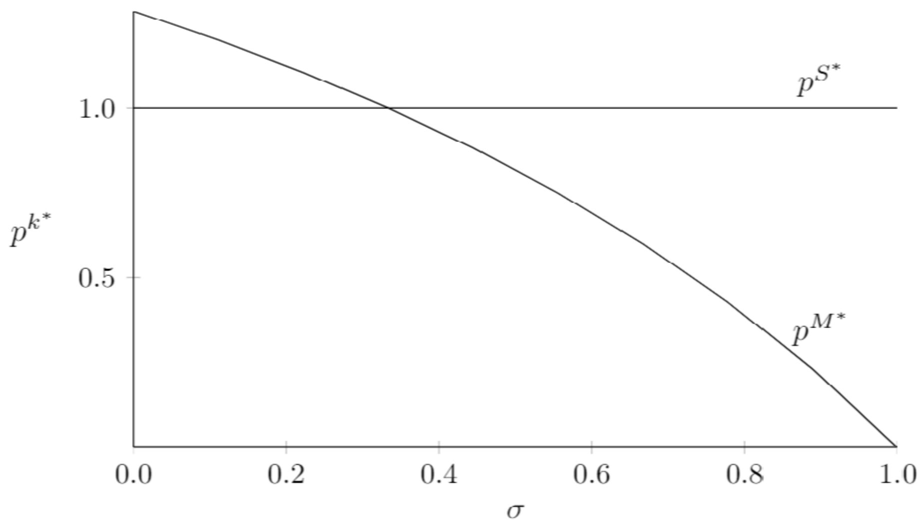

Figure 1.2: Equilibrium prices.

1.6.1 Comparison of equilibrium outcomes

Comparing the subscription prices in equation (1.15), we find that $p^{S^*} \geq p^{M^*}$ for $\sigma > \frac{2}{3}$. For lower σ, the single-homing price may be both greater and smaller than the multi-homing price, as illustrated in Figure 1.2 (parameter values: $t = 3\alpha$ and $\alpha = 1$).

When σ is low, the platforms have weaker incentives to reduce the multi-homing price. However, the higher t, the greater price reduction is required to persuade consumers to multi-home. Hence, if t is sufficiently high (the condition is given in the Appendix), the multi-homing price could still be lower than the single-homing price. Conversely, a higher σ (corresponding to shared consumers being more valuable) provides stronger incentives to reduce subscription prices in the multi-homing regime. This is why we observe that p^{M^*} decreases in σ, both in absolute value and relative to p^{S^*}.

Turning to advertising prices, we find that these are always lower with single-homing ($\alpha^{S^*} < \alpha^{M^*}$). Finally, we consider profits. We find that if $\sigma \geq 0.65$, single-homing profits cannot be greater than multi-homing profits ($\pi^{S^*} < \pi^{M^*}$). For $\sigma < 0.65$, however, profits may or may not be greater with single-homing. A sufficiently high t can ensure that single-homing makes the platforms better off. This is illustrated by Figure 1.3 (parameter values: $t = 3.3\alpha$ and $\alpha = 1$).[13]

From the analysis of subscription prices we know that consumers who subscribe to only

[13]We use different sets of parameter values in the two figures because it enables us to demonstrate that prices and profits can be both higher and lower with single-homing compared to multi-homing.

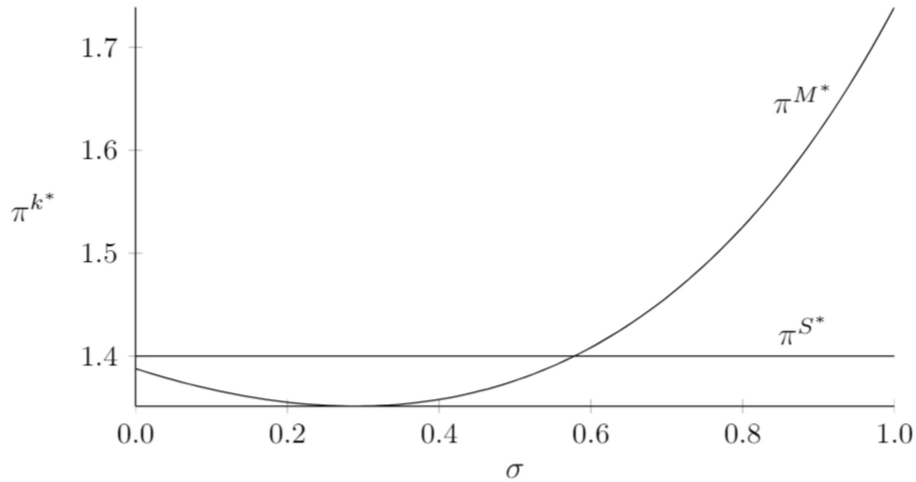

Figure 1.3: Equilibrium profits.

one platform are better off in a multi-homing regime when $\sigma > \frac{2}{3}$, since $p^{S^*} \geq p^{M^*}$.

Moreover, we find that at least some consumers prefer multi-homing over single-homing if $\sigma > \frac{2}{9}$.

The following proposition sums up the comparison of equilibrium outcomes:

Proposition 3 *Assume that condition 2 holds and that $\sigma > \frac{2}{3}$.*

Compared to pure single-homing, multi-homing provides

(i) lower subscription prices and higher consumer utility

(ii) higher ad revenues

(iii) higher platform profits

Proof. See Appendix. ■

By nature, single-homing profits do not depend on the value of shared consumers (σ). Multi-homing profits, on the other hand, are either increasing in σ or have a U-shaped relationship with σ. An increase in σ means that shared consumers are more valuable to advertisers. Since this allows the platforms to charge a higher ad price, one might expect that it would lead to greater platform profits. For most parameter values, profits are indeed unambiguously increasing in σ. An increase in the value of shared consumers also makes the platforms eager to attract more of them. But suppose that consumers have very strong platform preferences (high t). Attracting a larger audience may then require a price drop that is more costly than the additional revenue from gained consumers. This could be the case if the value of shared consumers, even after an increase, remains fairly low. Consequently, the overall impact on profits could be negative. However, as σ takes on higher values, profits will eventually start to increase. Figure 1.3 illustrates this U-shaped relationship between σ and multi-homing profits.

1.6.2 The existence of Nash equilibria

Next, we investigate whether single-homing and multi-homing constitute potential Nash equilibria. If shared consumers are sufficiently valuable, it pays off to charge lower subscription fees and forgo some subscription revenues in order to extract more ad-side revenues. Moreover, if the platforms set multi-homing prices, some consumers will actually subscribe to both platforms.

If, on the other hand, the advertiser valuation of shared consumers is low (small sigma), multi-homing might not constitute an equilibrium. In a situation with weak platform preferences (low t), a reduction in the subscription price would be efficient in attracting many consumers, making it tempting to undercut the rival's subscription price and only serve more valuable exclusive consumers. Both platforms would in that case deviate from multi-homing. However, as long as $\sigma > \sigma^* = 0.03$, we find that it is never beneficial for a platform to deviate from multi-homing. Recall that $\sigma \in (0, 1)$, which means that there is only a small interval where deviation from multi-homing might be feasible.

Then, consider the single-homing regime. Unless shared consumers have very little value for advertisers, the platforms have strong incentives to deviate from setting the single-homing price. More precisely, we find that it is profitable for a platform to deviate from single-homing for all $\sigma > 0.1$.

The most obvious reason is that deviation enables the platforms to sell more subscriptions and ad impressions. But even if shared consumers are not that valuable (i.e. $\sigma < 0.1$), single-homing does not constitute an equilibrium.

The single-homing prices would still be so low that some consumers would like to deviate and subscribe to both platforms.

We can state:

Proposition 4 *Assume that condition 2 holds. Then, there exists*

(i) a unique equilibrium with multi-homing for $\sigma > \sigma^*$

(ii) no equilibrium with single-homing for all $\sigma > 0$

Remark 1 *Multi-homing could also constitute an equilibrium for $\sigma < \sigma^*$, but only if consumers have sufficiently strong platform preferences.*

Proof. See Appendix. ■

The second result of Proposition 4 is particularly interesting. Previous literature has typically made the stark assumption of single-homing, which we find never takes part in a targeting equilibrium, and hence might not be an appropriate assumption to make.

1.7 Concluding remarks

This paper has two major contributions: First, we demonstrate the importance of consumer multi-homing. Multi-homing allows the platforms to attract more subscribers, which is increasingly valuable in the ad market when platforms use targeting technologies with increasing returns to scale in the audience size. Moreover, targeting does not trigger an aggressive price response from the rival platform, as would be the case in a single-homing regime. Altogether, we find that targeting can only be profitable if we relax the typically made single-homing assumption.

The second key contribution is an even more important one: we find that pure single-homing never occurs in equilibrium. This means that existing literature assuming single-homing might be misleading, and emphasizes that assessing the nature of consumer purchasing behavior (ie. single-homing or multi-homing) is vital to fully understand the impact of targeting.

Our set-up is partly motivated by the rise of first-party data. Until recently, consumer data could easily be purchased from third parties. However, increased demand for privacy has led to new regulations, such as the General Data Privacy Regulation (GDPR). Since GDPR came into force in 2018, compliance has been high on the business agenda, limiting the utilization of externally collected consumer information. Web browsers increasingly block third-party cookies, and platforms are moving away from third-party data and towards permission-based, internally collected first-party data.[14]

[14] See e.g. Goswami, S. (2020, November 9) and Walter, G. (2021, January 13).

The industry is already adapting to the new privacy-oriented landscape. Major platforms like The New York Times and The Washington Post have recently developed in-house solutions in order to control data and targeting.[15] The VP of commercial technology and development at The Washington Post, Jarrod Dicker, says (Washington Post Press release, July 16, 2019): *"User privacy is paramount to us, so we are deeply invested in building sophisticated tools powered by first-party data"*. The machine learning-based tools enable the newspaper to benefit from data on how the users engage with the platform, and reduce its reliance on cookie-driven information. The head of ad product for RED, Jeff Turner, elaborates (Washington Post Press release, July 16, 2019): *"Data points like a user's current page view and session on The Post's site are much more relevant to that user's current consumption intention than the information a cookie-driven strategy can offer"*. Advertisers cannot find this insight elsewhere, which gives the platforms a competitive advantage. The focus on privacy has increased the strategic importance of first-party data, which is also the key to successful targeting in our model.

Our model makes the assumption of ad-neutral consumers. Targeting could, however, either increase or reduce ad nuisance. On the one hand, privacy concerns might lead to less consumer satisfaction (Johnson, 2013; Kox *et al.*, 2017). On the other hand, more relevant ads could please them (Gong *et al.*, 2019). The overall effect is therefore ambiguous. We leave this analysis for future research. Our model specification says that the platforms' targeting ability increases at a constant rate as more consumers subscribe. While some sources claim that the more data, the better targeting results, others suggest that the benefit of more data will be diminishing at some point. We have not formally analyzed this issue, but we do not believe that it would change the key properties. Targeting would presumably still provide similar, but somewhat smaller effects.

We assume that advertisers' willingness to pay to reach a shared consumer is weakly lower than their willingness to pay to reach an exclusive consumer, i.e. $\sigma \in (0, 1)$. In an empirical study of US magazines, Shi (2016) finds that shared consumers are about half as valuable as exclusive consumers, i.e. $\sigma = \frac{1}{2}$. This estimate indicates that it is reasonable to assume that platforms must charge less for consumers that can be reached elsewhere.

One may also ask whether stricter privacy regulations provide greater incentives to cooperate in order to share data. On the one hand, joining forces to increase the total data

[15] See Fischer, S. (2020, May 19).

pool could be seen as an alternative to purchasing third-party data. On the other hand, stricter regulations might make cooperation less feasible. Furthermore, the perhaps greatest advantage of first-party data is that it provides the platforms with exclusive insight. This advantage clearly goes against sharing. Future studies could explore this issue further.

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Appendix

A.1 Conditions for multi-homing

Without targeting, second-order and stability conditions are always satisfied. From the equilibrium price, which is given by $p^M = \frac{v-\sigma\alpha}{2}$, we see that $v > \sigma\alpha$ is required for the price to be positive. The equilibrium demand functions are given by

$$x^e = \frac{1}{2}\frac{2t - v - \alpha\sigma}{t} \ ; \ x^{sh} = \frac{v + \alpha\sigma - t}{t} \text{ and } D^M = \frac{1}{2}\frac{v + \alpha\sigma}{t}.$$

The restriction of the analysis to partial multi-homing implies that we need $x^e > 0$ and $x^{sh} > 0$. This places some additional constraints on the parameter values: $\frac{1}{2}(v+\sigma\alpha) < t < v + \sigma\alpha$.

With targeting, stability requires $t > \frac{1}{2}\alpha(\sigma + 1)$ and the second-order condition is satisfied for $t > \sigma\alpha$. The equilibrium price is given by equation (1.15), and non-negative prices require that $t > \frac{\alpha v(3\sigma-1)}{v-\alpha}$. The equilibrium demand functions are

$$x^{e^*} = \frac{2t - v - 3\alpha\sigma}{2t + \alpha(1-3\sigma)} \ ; \ x^{sh^*} = \frac{\alpha + 2v + 3\alpha\sigma - 2t}{2t + \alpha(1-3\sigma)} \text{ and } D^{M^*} = \frac{\alpha + v}{2t + \alpha(1-3\sigma)},$$

for which partial multi-homing is ensured by $\frac{1}{2}(v + 3\alpha\sigma) < t < v + \frac{1}{2}\alpha(1 + 3\sigma)$.

Summarizing, this leaves us with the two binding constraints, depending on the value of σ:

Condition A.1 *(Multi-homing)* $\max\{\frac{1}{2}(v + 3\sigma\alpha), \frac{\alpha v(3\sigma-1)}{v-\alpha}\} < t < v + \sigma\alpha$ *for* $\sigma > \frac{1}{3}$.

Condition A.2 *(Multi-homing)* $\max\{\frac{1}{2}(v + 3\sigma\alpha), \frac{1}{2}\alpha(1 + \sigma)\} < t < v + \sigma\alpha$ *for* $\sigma \leq \frac{1}{3}$.

Finally, Condition A.1 constrains $v > \alpha\left(\sigma + \sqrt{\sigma(\sigma + 1)}\right)$.

A.2 Omitted proofs

Proof of Lemma 2

Under single-homing, this follows directly as $p^{S^*} - p^S = t - 2\alpha - (t - \alpha) = -\alpha < 0$. Under multi-homing, we have $p^{M^*} - p^M = \frac{1}{2}\frac{\alpha}{2t+\alpha(1-3\sigma)}(v - 2t(1 + \sigma) - 3v\sigma + \alpha\sigma - 3\alpha\sigma^2)$, which is negative if conditions A.1 and A.2 hold. ■

Proof of Lemma 3

Consider the single-homing regime. Suppose platform i targets ads, while platform j does not. The best-response functions are then

$$p_i(p_j) = \frac{t\,(t-2\alpha) + p_j\,(t-\alpha)}{2t-\alpha} \text{ and } p_j(p_i) = \frac{t + p_i - \alpha}{2}.$$

The equilibrium prices are given by (superscript 'd' for deviation)

$$p_i^d = \frac{3t^2 - 6\alpha t + \alpha^2}{3t-\alpha} \text{ and } p_j = \frac{3t^2 - 5\alpha t + \alpha^2}{3t-\alpha},$$

yielding profits

$$\pi_i^d = \frac{9}{4}t^2\frac{2t-\alpha}{(3t-\alpha)^2} \text{ and } \pi_j = \frac{1}{2}t\frac{(3t-2\alpha)^2}{(3t-\alpha)^2}.$$

From equation (1.17), we have the symmetric equilibrium profits when both platforms target and when none of the platforms targets.

The decision of whether or not to deviate can be formulated as a game matrix in Table A.1.

		Platform i	
		Target	Not target
Platform j	Target	$\frac{2t-\alpha}{4}, \frac{2t-\alpha}{4}$	$\frac{9}{4}t^2\frac{2t-\alpha}{(3t-\alpha)^2}, \frac{1}{2}t\frac{(3t-2\alpha)^2}{(3t-\alpha)^2}$
	Not target	$\frac{1}{2}t\frac{(3t-2\alpha)^2}{(3t-\alpha)^2}, \frac{9}{4}t^2\frac{2t-\alpha}{(3t-\alpha)^2}$	$\frac{1}{2}t, \frac{1}{2}t$

Table A.1: Prisoner's dilemma.

If platform j targets, it is optimal for platform i to target iff $\frac{2t-\alpha}{4} - \frac{1}{2}t\frac{(3t-2\alpha)^2}{(3t-\alpha)^2} = \frac{1}{4}\alpha\frac{3t^2-\alpha^2}{(\alpha-3t)^2} > 0$, which is always the case.

If platform j does not target, it is nevertheless optimal for platform i to target iff $\frac{9}{4}t^2\frac{2t-\alpha}{(3t-\alpha)^2} - \frac{1}{2}t = \frac{1}{4}t\alpha\frac{3t-2\alpha}{(3t-\alpha)^2} > 0$, which is also always the case.

Hence, platform i's dominant strategy is to target, regardless of the rival's decision, and despite targeting yielding lower profits than not targeting. This means that the platforms end up in a prisoner's dilemma when consumers single-home. ■

Proof of Proposition 2

To prove Proposition 2, we start by decomposing profits into ad revenues and subscription revenues.

Subscription revenues First, we show that subscription revenues are always lower with targeting:

$$p^{M^*}D^{M^*} - p^M D^M = -\tfrac{1}{4}\alpha^2\left(2t - v - \sigma\alpha - 2t\sigma + 3v\sigma + 3\alpha\sigma^2\right)\tfrac{2t-v+\alpha\sigma+2t\sigma+3v\sigma-3\alpha\sigma^2}{t(\alpha+2t-3\alpha\sigma)^2} < 0.$$

Ad revenues Ad revenues with targeting minus ad revenues without targeting are given by

$$A^{M^*} - A^M = \tfrac{1}{2}\alpha\tfrac{4t^2(1-\sigma)(v+2\alpha\sigma)+2tv^2(2\sigma-1)+2tv\alpha\sigma(9\sigma-5)+2t\alpha^2\left(5\sigma-13\sigma^2+12\sigma^3-1\right)-\alpha^2(2\sigma-1)(3\sigma-1)^2(v+\alpha\sigma)}{t(2t+\alpha-3\alpha\sigma)^2}.$$

We find it useful to consider $\sigma > \frac{1}{3}$ and $\sigma < \frac{1}{3}$ separately.

For $\sigma > \frac{1}{3}$, we have that $v_{\min}$ ensures higher profits with targeting:

$$A^{M^*} - A^M|_{v=\alpha} = \tfrac{\alpha}{2t}\tfrac{\left(4t^2\alpha(2\sigma+1)(1-\sigma)+4t\alpha^2\left(\sigma-2\sigma^2+6\sigma^3-1\right)-\alpha^3(\sigma+1)(2\sigma-1)(3\sigma-1)^2\right)}{(2t+\alpha-3\alpha\sigma)^2} > 0.$$

Moreover, the difference between profits with and without targeting becomes greater as v increases:

$$\tfrac{d(A^{M^*}-A^M)}{dv} =$$
$$\tfrac{1}{2t}\tfrac{\alpha}{(2t+\alpha-3\alpha\sigma)^2}\left(4t^2(1-\sigma) + 2t\alpha\sigma(9\sigma-5) + 4tv(2\sigma-1) - \alpha^2(2\sigma-1)(3\sigma-1)^2\right) > 0.$$

Hence, $A^{M^*} > A^M$ for all $\sigma > \frac{1}{3}$.

We then consider $\sigma \leq \frac{1}{3}$. If t is low, a reduction in the subscription price will turn many exclusive consumers into shared consumers. But if the shared consumers are not worth much in the ad market, the benefit for the platform is limited. This implies that even though targeting increases the ad price, it does not necessarily increase ad revenues when $\sigma < \frac{1}{3}$. We illustrate with an example:

Suppose that $\sigma = 0$, which yields

$$A^{M^*} - A^M = \alpha\frac{(2t-v)\left(2tv-\alpha^2\right)}{2t\left(2t+\alpha\right)^2}$$

The expression is positive if $2tv > \alpha^2$. If t and v are not sufficiently high relative to α, this is not the case. Consider, for instance, $v = 0.6$, $t = 0.55$ and $\alpha = 1$. The numerator $(2t - v)(2tv - \alpha^2)$ then equals -0.17, which implies that $A^{M^*} - A^M < 0$.

Platform profits We then analyze the platform profits. By inserting equations (1.15) and (1.14) into (1.8), we find the equilibrium profits with and without targeting, respectively, when consumers multi-home:

$$\pi^{M^*} = \frac{(t-\alpha\sigma)(\alpha+v)^2}{(\alpha(1-3\sigma)+2t)^2} + \frac{\alpha(2t-v)}{(\alpha(1-3\sigma)+2t)} - \alpha\sigma\left(1 + \frac{2\alpha - v}{\alpha(1-3\sigma)+2t}\right) \tag{A.1}$$

and

$$\pi^M = \frac{1}{4t}(v^2 + 2v\alpha(2\sigma-1) + 3\alpha^2\sigma^2 - 2\alpha^2\sigma - 4t\alpha(1-\sigma)). \tag{A.2}$$

Whether higher ad revenues compensate for lower subscription revenues is dependent on σ. We start by considering $\sigma > \frac{1}{3}$. The minimum $v-$value is given by $v_{\min} = \alpha + \varepsilon$. By definition, $\sigma_{\min} = \frac{1}{3} + \varepsilon$. Evaluating multi-homing profits of equation (A.1) and (A.2) at $v_{\min}$ and $\sigma_{\min}$, we have that targeting in both cases provides greater profits ($\pi^{M^*} > \pi^M$):

$$\pi^{M^*} - \pi^M|_{v\min} \approx \tfrac{1}{4}\alpha^2 \tfrac{(2t-\alpha)^2 + 9\alpha\sigma^3(4t-3\alpha\sigma) + 6\sigma^2\left(-2\alpha t + 3\alpha^2 - 2t^2\right) - 4\sigma\left(\alpha t + 2\alpha^2 - 2t^2\right)}{t(2t+\alpha-3\alpha\sigma)^2} > 0$$

and

$$\pi^{M^*} - \pi^M|_{\sigma\min} = \tfrac{1}{12}\tfrac{\alpha}{t^2}\left(4tv - (v+\alpha)^2\right) > 0.$$

Moreover, for $v_{\min}$ we have that $(\pi^{M^*} - \pi^M)$ is increasing in σ :

$$\tfrac{d(\pi^{M^*} - \pi^M)}{d\sigma}|_{v\min} \approx \tfrac{1}{2}\tfrac{\alpha^2(\alpha^3(3\sigma+1)(3\sigma-1)^3 - 8t^3(3\sigma-1) - 2\alpha^2 t\left(-9\sigma - 27\sigma^2 + 81\sigma^3 + 11\right) + 12\alpha t^2\left(-2\sigma + 9\sigma^2 + 1\right)}{t(\alpha+2t-3\alpha\sigma)^3} > 0.$$

Similarly, $(\pi^{M^*} - \pi^M)$ is increasing in v for $\sigma_{\min}$:

$$\tfrac{d(\pi^{M^*} - \pi^M)}{dv}|_{\sigma\min} = \tfrac{1}{6t^2}\alpha\left(2t - v - \alpha\right) > 0.$$

Finally, higher $v-$values enhance the increase in $(\pi^{M^*} - \pi^M)$ in response to a change in σ :

$$\frac{d\left(\frac{d(\pi^{M^*}-\pi^M)}{d\sigma}\right)}{dv} = \frac{1}{2}\alpha\frac{2\alpha^3(3\sigma-1)^3+12\alpha t^2(5\sigma-1)-4\alpha^2 t\left(5-18\sigma+27\sigma^2\right)+4tv(4t-\alpha-3\alpha\sigma)-8t^3}{t(\alpha+2t-3\alpha\sigma)^3} > 0.$$

The numerator is increasing in v, and since it is positive for $v_{\min}$ it is also positive for larger $v-$values. In sum, targeting is profitable if $\sigma > \frac{1}{3}$.

Consider then the case where $\sigma < \frac{1}{3}$. In this case, targeting does not necessarily increase ad revenues. Since targeting also reduces subscription revenues, it might lead to lower profits. ■

Proof of Proposition 3

The proof consists of three parts:

(i) a) **Subscription prices:** The subscription prices are given in equation (1.15). The difference in the prices, $p^{S^*} - p^{M^*} = \frac{15\alpha^2\sigma-5\alpha t-5\alpha^2+2t^2-3\alpha t\sigma}{\alpha+2t-3\alpha\sigma}$, is greater than zero for $\sigma > \frac{2}{3}$. For lower values of σ, this requires the additional constraint

$$t > \frac{1}{4}\left(\sqrt{\alpha^2(9\sigma^2-90\sigma+65)}+3\alpha\sigma+5\alpha\right).$$

b) **Consumer utility:** To show that consumer utility is higher with multi-homing, we need to compare the utility from subscribing to one platform with that of subscribing to two platforms. The utility from subscribing to one platform only is $u_i^{p=p^{S*}}(x=1/2) = 5\alpha - \frac{3}{2}t$, whereas the utility from subscribing to both platforms is given by $u_{i+j}^{p=p^{M^*}}(x=1/2) = t\frac{7\alpha-2t+3\alpha\sigma}{\alpha+2t-3\alpha\sigma}$. Multi-homing is preferred if

$$u_{i+j}^{p=p^{M^*}} - u_i^{p=p^{S*}} = \frac{1}{2}\frac{30\alpha^2\sigma-3\alpha t-10\alpha^2+2t^2-3\alpha t\sigma}{\alpha+2t+3\alpha\sigma} > 0,$$

which holds for $\sigma > \frac{2}{9}$. From the analysis of subscription prices, we know that consumers who subscribe to only one platform are also better off when $\sigma > \frac{2}{3}$. Hence, a sufficient condition for all consumers to be better off with multi-homing is that $\sigma > \frac{2}{3}$.

(ii) **Ad prices:** The ad prices are given by

$$\alpha^{M^*} = \alpha\frac{(2t+5\alpha-3\alpha\sigma)}{(2t+\alpha-3\alpha\sigma)} \text{ and } \alpha^{S^*} = \frac{3}{2}\alpha.$$

The difference in ad prices $\alpha^{S^*} - \alpha^{M^*} = -\frac{1}{2}\alpha\frac{(7\alpha-2t+3\alpha\sigma)}{2t+\alpha-3\alpha\sigma} < 0$, which states that the ad price is always higher with multi-homing.

(iii) **Profits:** The platform profits are given by equations (A.1) and (A.2). The difference is given by

$$\pi^{S^*} - \pi^{M^*} = \frac{\left(36\alpha^3\sigma^3 - 3\alpha^2\sigma^2(7\alpha+10t) + 2\alpha\sigma\left(16\alpha t + 17\alpha^2 - 4t^2\right) + 4t^2(2t-3\alpha) - \alpha^2(50t-11\alpha)\right)}{4(\alpha+2t-3\alpha\sigma)^2}.$$

We find that single-homing profits cannot be greater than multi-homing profits if $\sigma \geq 0.65$ when Condition 2 holds.

■

Proof of Proposition 4

A stable equilibrium is one in which no player will deviate from a given strategy. We first examine the incentives to deviate from a multi-homing price setting, and then the incentives to deviate from a pure single-homing outcome. Finally, we find that the consumers facing single-homing prices will always deviate and subscribe to an additional platform, such that single-homing can never be part of an equilibrium.

(i) Deviation from multi-homing

Suppose that platform i believes that the rival prices according to the multi-homing regime: $p_j = \frac{v(t+\alpha)-\alpha(t+3v\sigma)}{2t+\alpha(1-3\sigma)}$. Could it be optimal for platform i to charge a higher price and only sell to consumers that do not subscribe to platform j?

We insert $p_j = \frac{v(t+\alpha)-\alpha(t+3v\sigma)}{2t+\alpha(1-3\sigma)}$ into the location of the indifferent consumer:

$$\widetilde{x} = \frac{1}{2} + \frac{p_j - p_i}{2t},$$

which yields

$$D_i = \frac{1}{2}\frac{2t^2 + 3\alpha t + 3\alpha^2 - 3\alpha\sigma\left(3\alpha + t\right) - p_i\left(\alpha + 2t - 3\alpha\sigma\right)}{t\left(\alpha + 2t - 3\alpha\sigma\right)}$$

and subscription price (superscript ‘d’ for deviation):

$$p_i^d = \frac{(2t - 3\alpha)\left(\alpha t + \alpha^2 + t^2\right) - 3\alpha\sigma\left(t^2 + \alpha t - 3\alpha^2\right)}{(2t - \alpha)\left(\alpha + 2t\right) - 3\alpha\sigma\left(2t - \alpha\right)}.$$

Compared to the equilibrium price with multi-homing, the deviation price is always higher if $\sigma > \frac{2}{3}$. The deviation profit is given by

$$\pi_i^d = \frac{1}{4}\frac{\left(12\alpha^2\sigma - 5\alpha t - 4\alpha^2 - 2t^2 + 3\alpha t\sigma\right)^2}{\left(2t-\alpha\right)\left(-\alpha - 2t + 3\alpha\sigma\right)^2}.$$

Comparing deviation profits with the multi-homing equilibrium profit, we find that

$$\pi_i^d - \pi^{M^*} = \frac{1}{4}\frac{4t^4+4\alpha t^3(5\sigma-3)-3\alpha^2t^2\left(10\sigma+29\sigma^2+13\right)+8\alpha^3t(3\sigma+7)\left(2-3\sigma+3\sigma^2\right)-4\alpha^4(\sigma-1)\left(1-30\sigma+9\sigma^2\right)}{(2t-\alpha)(-\alpha-2t+3\alpha\sigma)^2}.$$

The above shows that deviation is never profitable if $\sigma > 0.03$.

However, for multi-homing to be an equilibrium, it must be true that consumers will actually purchase both products when $p = p^{M^*}$.

From

$$u_i^{p=p^{M^*}}(x = \frac{1}{2}) = \frac{1}{2}t\frac{7\alpha - 2t + 3\alpha\sigma}{\alpha + 2t - 3\alpha\sigma}$$

and

$$u_{i+j}^{p=p^{M^*}}(x = \frac{1}{2}) = t\frac{7\alpha - 2t + 3\alpha\sigma}{\alpha + 2t - 3\alpha\sigma},$$

we see that $u_{i+j}^{p=p^M} - u_i^{p=p^M} = \frac{1}{2}t\frac{7\alpha-2t+3\alpha\sigma}{\alpha+2t-3\alpha\sigma} > 0$ whenever Condition 2 holds, which confirms that some consumers want to multi-home. Hence, (some) multi-homing consumers have no incentives to deviate (subscribe to only one platform) when facing multi-homing prices, and there is a unique equilibrium with multi-homing. ■

(ii) Deviation from single-homing

If both platforms price according to single-homing, prices and profits are given by $p^{S^*} = t - 2\alpha$ and $\pi^{S^*} = \frac{1}{4}\left(2t-\alpha\right)$. Suppose that platform i believes that platform j sets the single-homing price, p^{S^*}. If platform i deviates and sets the prices that maximize profits if also selling to some consumers who buy the rival's product, we get:

$$p_i^d = \frac{\alpha t\left(\sigma+1\right) - \alpha^2\left(11\sigma - 5\right)}{2(t-\alpha\sigma)}.$$

Deviation profit is given by:

$$\pi_i^d = \frac{1}{4}\alpha\frac{25\alpha^3\left(\sigma-1\right)^2+8t^3\left(1-\sigma\right)+\alpha t^2\left(2\sigma+9\sigma^2+5\right)-10\alpha^2 t\left(1-\sigma\right)\left(5-3\sigma\right)}{t^2\left(t-\alpha\sigma\right)}$$

and

$$\pi_i^d - \pi^{S^*} = \frac{1}{4}\frac{-2t^4+25\alpha^4\left(\sigma-1\right)^2-10\alpha^3 t\left(1-\sigma\right)\left(5-3\sigma\right)+\alpha^2 t^2\left(\sigma+9\sigma^2+5\right)+3\alpha t^3\left(3-2\sigma\right)}{t^2\left(t-\alpha\sigma\right)}.$$

Examining the above equations shows that deviation is profitable when $\sigma > 0.1$. For $t-$values in the higher end of Condition 2, it might also be the case for $\sigma < 0.1$.

Suppose next that for some $\sigma < 0.1$, it is optimal for the platforms to set the single-homing price. This can only be an equilibrium if the consumers do not subscribe to both platforms at this price. We insert p^{S^*} into (1.1) and (1.3) for $x = \frac{1}{2}$ and find

$$u_i^{p=p^{S^*}}(x=\frac{1}{2}) = \frac{1}{2}\left(10\alpha-3t\right)$$

and

$$u_{i+j}^{p=p^{S^*}}(x=\frac{1}{2}) = 10\alpha-3t.$$

We see that $u_{i+j}^{p=p^{S^*}} > u_i^{p=p^{S^*}}$, which implies that there exist consumers who want to subscribe to both platforms when $p = p^{S^*}$. By the same token, deviation is only possible if some consumers actually subscribe to both platforms at the deviation price. We insert p^{S^*} and p_i^d into (1.1) and (1.3), respectively, and find

$$u_i^{p=p^{S^*}}(x=\frac{1}{2}) = \frac{1}{2}\left(10\alpha-3t\right)$$

and

$$u_{i+j}^{p=p_i^d}(x=\frac{1}{2}) = \frac{1}{2}\frac{3\alpha t\left(\sigma+5\right)-5\alpha^2\left(\sigma+1\right)-4t^2}{t-\alpha\sigma}.$$

At $x = \frac{1}{2}$, $u_{i+j}^{p=p_i^d} > u_i^{p=p^{S^*}}$, and there exist consumers who want to multi-home. Some consumers have incentives to deviate and subscribe to more platforms when facing single-homing prices. Therefore, single-homing can never take part in an equilibrium. ■

A.3 Robustness

In the equilibrium analysis, we assume that $v = 3\alpha$. This provides us with a more tractable set of constraints. The drawback is that it might bring the robustness of the findings into question. To shed some light on this issue, we take a closer look at how the results depend on v.

First, note that π^{S^*} does not depend on v, while $\partial\pi^{M^*}/\partial v > 0$ if $v > \mu \equiv \frac{\alpha^2\left(1-2\sigma+3\sigma^2\right)-2\alpha t\sigma}{2(t-\alpha\sigma)}$. Since $\partial\mu/\partial t < 0$, the requirement is strictest for $t_{\min}$. From the conditions, we know that the lowest possible t is given by $\frac{5}{2}\alpha$. This gives $\mu|_{t=2\alpha} = \alpha\frac{7\sigma-3\sigma^2-1}{2\sigma-5}$, which is at its highest when $\sigma = 0$ and yields $\mu = \frac{1}{5}\alpha$. Hence, multi-homing becomes relatively more profitable compared to single-homing for all $v > \frac{1}{5}\alpha$.

We then consider how v affects the platforms' incentives to deviate from committing to single-homing and multi-homing. Suppose that we do not fix v. If the rival commits to single-homing, the deviation profit is given by

$$\pi_i^{d,S} = \frac{1}{4}\frac{t^2v(v+2\alpha\sigma)+\alpha^2(\sigma-1)^2(2\alpha+v)^2+8\alpha t^3(1-\sigma)-2\alpha tv(\sigma-1)(-4\alpha-v+3\alpha\sigma)+\alpha^2t^2\left(-4\sigma+9\sigma^2-4\right)-4\alpha^3t(3\sigma-2)(\sigma-1)}{t^2(t-\alpha\sigma)}.$$

Consequently, $\frac{d(\pi_i^d-\pi^{S^*}))}{dv} > 0$ if $v > \lambda \equiv \frac{\alpha^2t(\sigma-1)(3\sigma-4)-2\alpha^3(\sigma-1)^2-\alpha t^2\sigma}{(t-\alpha+\alpha\sigma)^2}$. This is ensured by condition $(t < v + \sigma\alpha)$ for all $\sigma > 0.01$.

Proof:

$v > t - \sigma\alpha > \lambda$ if $t - \sigma\alpha - \lambda > 0$. We have that:

$$t - \sigma\alpha - \lambda = \frac{t^3 + \alpha^3\left(2-\sigma\right)\left(\sigma-1\right)^2 + t\alpha^2\left(4\sigma-3\right)\left(1-\sigma\right) - 2t^2\alpha\left(1-\sigma\right)}{\left(t-\alpha+\alpha\sigma\right)^2}$$

The expression is greater than 0 for all $\sigma > 0.01$. ■

Unless multi-homing consumers are almost worthless in the ad market, it is certainly more tempting to deviate from single-homing if v increases from 3α.

Similarly, we consider the case with the rival committing to multi-homing. Deviation profit is then

$$\pi_i^{d,M} = \frac{1}{4}\frac{\left(2t\alpha + v\alpha + \alpha^2 - 3\alpha^2\sigma + tv + 2t^2 - 3t\alpha\sigma - 3v\alpha\sigma\right)^2}{\left(2t-\alpha\right)\left(2t+\alpha-3\alpha\sigma\right)^2}$$

From the profit expression, we find that $\frac{d(\pi_i^d - \pi^{M*})}{dv} < 0$ if

$$v > \mu \equiv \frac{2t^3 - \alpha^3\left(3\sigma+1\right)\left(1-\sigma\right) - t^2\alpha\left(17\sigma-4\right) + t\alpha^2\left(7-16\sigma+21\sigma^2\right)}{\left(t-\alpha+\alpha\sigma\right)\left(7t+\alpha-9\alpha\sigma\right)}.$$

This is ensured by condition $(t < v + \sigma\alpha)$ for all $\sigma > 0.02\dot{6}$.

Proof:

$v > t - \sigma\alpha > \mu$ if $t - \sigma\alpha - \mu > 0$. We have that

$$t - \sigma\alpha - \mu = \frac{5t^3 + \alpha^3\left(1-\sigma\right)\left(4\sigma - 9\sigma^2 + 1\right) - 4t\alpha^2(2 - 8\sigma + 7\sigma^2) + 2t^2\alpha\left(4\sigma - 5\right)}{\left(t-\alpha+\alpha\sigma\right)\left(7t+\alpha-9\alpha\sigma\right)}$$

is positive for $\sigma > 0.026$. ■

Deviation is less tempting if v increases from 3α, at least if $\sigma \geq 0.02\dot{6}$.

Suppose that $\sigma = 0$, which yields $\mu_{\max} = \frac{1}{(t-\alpha)(7t+\alpha)}\left(2t^3 + 4t^2\alpha + 7t\alpha^2 - \alpha^3\right)$ since $\frac{d\mu}{d\sigma} < 0$. For $t \equiv t' \leq 6.57\alpha$, we find that $v \geq 3\alpha \geq \mu$.

$\frac{d\mu_{\max}}{dt'} > 0$. We have that $v > t'$ (condition $(t < v + \sigma\alpha)$). This implies that if $t' > \mu_{\max}$, then $v > \mu_{\max}$. Since

$$t' - \mu_{\max} = \frac{\alpha^3 - 8t\alpha^2 - 10t^2\alpha + 5t^3}{\left(t-\alpha\right)\left(7t+\alpha\right)} > 0$$

Deviation is less tempting for $v > 3\alpha$ also if $\sigma = 0$.

In this section, we have shown that our results are quite robust. Given that multi-homing consumers are not negligible in the ad market, our results hold for all $v > 3\alpha$. A higher v does not make single-homing more attractive relative to multi-homing and it does not reduce the incentives to deviate from single-homing. Moreover, a higher v makes it less imperative to deviate from multi-homing. Evaluating $v-$values below 3α is less interesting since the lower boundary is given by $v = 2.75\alpha$.

Consumers

For a general v, we check whether consumers will subscribe to both platforms when $p = p^{M^*}$. Inserting (1.15) into (1.1) and (1.3), we find:

$$u_i^{p=p^{M^*}}(x = \frac{1}{2}) = \frac{1}{2}t\frac{2v + \alpha + 3\alpha\sigma - 2t}{2t + \alpha - 3\alpha\sigma}$$

and

$$u_{i+j}^{p=p^{M^*}}(x = \frac{1}{2}) = t\frac{2v + \alpha + 3\alpha\sigma - 2t}{2t + \alpha - 3\alpha\sigma}.$$

It follows that if $u_{i+j}^{p=p^{M^*}} > u_i^{p=p^{M^*}}$ for $v = 3\alpha$, the same is true for any other v-value as well. ■

Chapter 2

Co-location, good, bad or both: How does new entry of discount variety stores affect local grocery business?

Co-location, good, bad or both: How does new entry of discount variety stores affect local grocery business?*

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Abstract

We analyze 69 entries and relocations by the Norwegian discount variety chain Europris during the period 2016 to 2019. We measure how its location choices affect local grocery stores' performance, using a diff-in-diff strategy and data from a large Norwegian grocery chain. We combine detailed data on local grocery stores' sales, traffic and travelling distance to new or relocated Europris stores. We find that entries and relocations have significant effects, suggesting an S-shaped relationship; sufficiently close entries increase local demand since more customers are attracted to the market, but, as the distance increases, the competitive effect of a new discount variety store dominates, and local grocery sales and traffic are reduced. As we move further away, the entry effect is gradually reduced to zero. We show that this empirical finding can be squared with a simple theoretical model. Our results confirm theoretical conjectures on agglomeration forces and competitive effects from local competition.

Keywords: Retail economics, local competition effects, positive agglomeration forces, grocery markets.

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2.1 Introduction

In this paper, we explore the rise of discount variety retail and how this has changed the competition towards grocery stores. Over time, grocery stores have broadened their product range into everything from books to consumer electronics. Likewise, we see a growing trend where earlier specialized retailers like "dollar stores" and general hardware stores add groceries to their product range. In 2019, the American discount variety chain Dollar General expanded its product range to also include fresh grocery products, and since 2003 they have offered food products in a number of stores.[1] Today, Dollar General delivers grocery products to more than 9,000 of its total 16,500 locations.

We have also seen a strong trend in retail towards stores co-locating in malls and business areas. In this new retail landscape where different chains may both compete and complement each other, store location choices become less obvious. On one hand, differences in product range might lead to increased traffic and number of customers when stores locate very close to one another. On the other hand, increased local competition for the products that are offered by both chains reduces incentives to co-locate.

To understand how this new mix of product ranges and reduced retail chain specialization affect store localization, we analyze the location behavior of the biggest discount variety chain in Norway, Europris. In particular, we analyze how its location choices affect one of the largest grocery chains in Norway. Europris has been one of the most successful retail chains in Norway, establishing a number of new stores across the country. The grocery chain is among the leading discount grocery players in Norway. It serves more than 20% of the national market alone, and is represented across all major regions in Norway. More than one third of the grocery chain's product categories are also offered by Europris, and in terms of sales, as much as one fourth of the grocery chain's turnover is stemming from these product categories.

Benefiting from a very detailed grocery data set covering all transactions before and after the arrival of competing discount variety stores, we use a diff-in-diff approach to estimate the effect of entry. More specifically, we analyze how sales and customer traffic in local stores within the grocery chain is affected by Europris establishments and relocations as compared to a large control group of grocery stores that are not affected by changes in Europris

[1] The first store appeared in 1939, and in 1955 they took the name Dollar General. Hence, only after 64 years did they expand into food items.

locations. In all models, we control for local competition and local demographics, including separate detailed control variables varying on the municipal level. We also have detailed information on the product overlap between Europris and the grocery chain, allowing us to estimate separate effects for products that are offered by both chains and products that are only offered by the grocery chain.

In the case we consider, an incumbent grocery store may be affected by the establishment of a discount variety store with partially overlapping product ranges in two ways. On the one hand, because the stores only compete on a subset of their product categories, the grocery store may get new customers due to the increased quality of their location stemming from the complementarities across stores. Let us think about this as an increase in the extensive margin: As long as the entering store is differentiated enough with regards to product range, this co-location effect is likely to be positive (positive demand effect). This positive effect of establishment should be stronger the closer the new establishment is located to the incumbent grocery store, and maximized if co-location allows for one-stop shopping. On the other hand, entry will increase competition for the product categories offered by both stores. This can be interpreted as a reduction in the intensive margin: some of the incumbent's existing customers may choose to purchase some products that they used to buy at the incumbent grocery store at the entrant discount variety store (fiercer competition).[2] This effect will be negative, and stronger the closer the establishment is to the grocery store.

The net effect of the two effects outlined above is not clear. Furthermore, while we expect both the positive and negative effects to decrease in size with distance, they may do so at different rates and thereby give rise to a non-monotonic relationship between distance between the stores and sales at the incumbent grocery store. For example, it may be that the agglomeration effect is important when the stores are fairly close, while the competition effect continues to be important also when the distance is relatively large.

In our empirical analysis, we find that one-stop shopping leads to positive agglomeration effects, increasing local demand when new stores enter. Perhaps more surprising, our results provide some support that this holds true both for competing products (offered by both chains) and non-competing products (offered only by the grocery chain). We also find clear

[2]The increased competition might also affect prices, but in our case the incumbent is already using national prices, and thus the effect of the new store will come through changes in sales.

evidence for a competitive effect that decreases with distance between the stores. What we find particularly intriguing is that the interplay between the positive agglomeration forces and the competition effect creates an S-shaped pattern: positive agglomeration forces dominate for one stop co-locations, but as stores are located further apart, the negative competition effect gets relatively larger. At some point, the competition effect becomes dominant before it eventually tapers off. The S-shaped relationship between grocery sales and distance to the newly established discount variety store suggests that the interplay of the positive agglomeration effect and the negative competitive effect varies with distance between the stores.

To gain some additional insight into the mechanisms at play, we develop a simple theoretical model that fits our empirical case closely. Using a framework inspired by Hotelling (1927), we consider how an incumbent store is affected by the entry of a competitor in its vicinity. The entrant offers a substitute to one of the incumbent's products at a lower price. This increases the overall value of shopping in the area where the two stores are located. While greater competition for products that are sold in both stores reduces the incumbent's sales to existing customers, the improved quality of the location attracts new customers. We find that the overall effect on sales may have an S-shape similar to what we observe in the empirical analysis. Assuming that one-stop shopping is feasible and provides an additional benefit, the increased sales to new customers outweigh the lost sales due to existing customers buying the substitute from the entrant. However, if the distance between the stores prevents one-stop shopping, the competition effect prevails. In line with the empirical results, we find that also the competition effect eventually fades out as the distance between the stores becomes sufficiently large.

We now discuss our empirical results in more detail. In our first main empirical analysis, we use a diff-in-diff approach to estimate the effect of establishments of discount variety stores on grocery stores' sales. When we distinguish between the new entries that allow for one-stop shopping and those that require customers to stop twice, we see a distinct pattern: one-stop shopping increases sales by nearly 9%, whereas entries that require the customers to stop twice have a negative impact on the incumbents' sales (-4%). The same pattern holds for store traffic.

The next question we address is how the magnitude of the two effects depend on the distance between the incumbent and the new store. We explore this question by splitting the two-stop shopping entries into different distance bins and re-estimating our models. We now uncover an intriguing pattern. When we move away from one-stop shopping and up to a distance of two km, we find a small negative effect (for competing products) on sales from new entries (-3%). For entries between two and five km away, the negative effect (for all products) is much larger (-7% to -9%), although it gets smaller and ultimately fades off for entries even further away.

We attribute this S-shape to the interplay between the two margins. For the entries relatively close by (250 meters to two km), the extensive margin effect of higher local demand still has some influence, though the intensive margin effect of fiercer competition dominates. As we move further away (in our case beyond two km), the competition effect peaks, generating the maximum negative overall effect. And as we move even further away in distance, the net effect goes towards zero, which is what we would expect given that both effects should taper off eventually. Interestingly, we find much the same pattern for both competing and non-competing product categories, but the effects are, not surprisingly, higher for the former group.

We show that the results are robust to including controls for local competition, demographics and cases where the change in distance is so small that we are unable to tell whether the distance has actually decreased. We also perform a Granger test to examine the presence of anticipatory effects and reverse causality, concluding that the test is consistent with our econometric diff-in-diff models.

Related literature Stahl (1982) was one of the first to model the trend towards co-location and one-stop shopping behavior theoretically. He models how the changes in the sellers' market demand influence location choices. In particular, he decomposes two effects: a negative substitution effect generated by competition for consumers' demand and a positive market area effect generated from joint location of sellers. If the increase in demand from joining the bigger market is higher than the effect of fiercer competition, co-location becomes the optimal choice. This will in turn become a positive externality for the incumbents already there. Stahl finds that co-location is an equilibrium outcome as long as customers are choosy enough about the variety of commodities.[3]

[3]There are several theoretical studies modelling store choice and store location. Beggs (1994) looks at the rationale for malls rather than large department stores by modelling demand and pricing complementarities. Smith and Hay (2012) model competition between shopping centers, in particular, how

Our study speaks to the empirical literature on store choices. Messinger and Narasimhan (1997) formulate and estimate a model on grocery data that aims to explain the growth in one-stop shopping. Using U.S. data, they find that increased income and reduced store operation costs have both increased supermarket assortment and the gains from one-stop shopping. Over the period 1961-1986 they find that reduction in shopping time has led to a 2.2% reduction of households' expenditures on grocery products. Bell et al. (1998) model store choice behavior based on fixed and variable cost of shopping, attributing the former to the shopping list (products and quantities) and the latter to travel cost and store loyalty. They abstain from differences in store assortment. They also take the model to data for a bigger U.S. city, and find support for fixed cost – shopping list heterogeneity being a major factor behind store choices. Fox et al. (2004) undertake an exploratory analysis estimating a model on consumer reported data on purchases to understand how marketing policies affect shopping behavior across retail store formats. Vitorino (2012) looks at how positive and negative spillovers among firms affect location choices. She finds empirical support for firms co-locating despite potential business stealing effects. Her results suggest that the size of these effects determines the number of firms that can operate in a given local market. Picone et al. (2009) suggest that even if competitive forces make firms prefer distancing, they might end up co-locating because of few location options. Not surprisingly, this seems to be a more likely outcome among firms selling differentiated products. Related to the questions on store choices, Thomassen et al. (2017) study pricing in supermarkets. They estimate cross-category pricing effects, and find that the effects are higher the more consumers that prefer one-stop shopping. This has to do with these consumers being inclined to switch all their purchases to another store in response to a price change on one product category. Since supermarkets fully internalize the cross-category pricing effects (in contrast to specialized stores), one-stop shopping contributes to greater price competition.

Several empirical studies have analyzed spatial competition between retail outlets more generally. Lindsey et al. (1991) analyze the video-cassette-retail market in Alberta to understand product variety and pricing. In a more recent study of the video-retail market, Seim (2006) finds empirical support for firms using spatial differentiation in order to reduce

agglomeration effects between products are accommodated through different organizational structures and to which extent competition in prices and product quality is internalized. They consider three scenarios: streets (no internalization), malls (developers internalize) and supermarkets (where both shops and developer internalize).

local competition. Smith (2004) estimates consumer choice in the U.K. supermarket industry using data on profit margins to deduct price parameters in consumer utility. Davis (2004) estimates a demand model where products are location specific and consumers have preferences over geographic proximity and store/product characteristics, to understand substitution patterns between U.S. motion picture exhibition theaters. He concludes that travel costs result in limited theater (store) substitutability and localized markets. Houde (2012) estimates a structural model of spatial competition using consumers' commuting paths as instruments for the consumers' locations in a Hotelling-like model, using data from the Quebec City retail gasoline market. Based on the model, he simulates the effects of a merger, and shows that compared to a reduced form diff-in-diff analysis of the actual merger, the spatial model performs well. Turola (2016) estimates the intensity of competition in the French grocery retail sector. She builds a structural spatial competition model, where demand depends on both geography and heterogeneity in the customers' shopping lists. She recovers price-cost margins, and finds that the competitive pressure is very localized and depends on the presence of nearby competitors.

The paper is organized as follows. Section 2.2 discusses our empirical strategy, Section 2.3 presents the data and takes a first look at the market. In Section 2.4 we present and discuss our econometric results, and robustness is discussed in Section 2.4.3. In Section 2.5 we present a simple theory framework where we discuss the estimated effects, and we also simulate an outcome mirroring the empirical findings. Section 2.6 concludes.

2.2 Empirical strategy

We want to explore how proximity to a discount variety store (in our case, Europris) affects grocery store sales. Our empirical strategy exploits the fact that during our sample period, 69 Europris stores were established or relocated. Some grocery stores in our sample were affected by a Europris establishment in the sense that the distance to the closest Europris store changed after the establishment or relocation, while others were unaffected, enabling us to use a diff-in-diff approach to estimate the effect on grocery store sales of having a discount variety store in the vicinity.[4]

[4] We focus on grocery stores that experience a reduction in distance to the closest Europris store. During our sample period, the locations of all grocery stores are fixed, implying that any changes in distance stem from Europris entries or relocations.

We refer to grocery stores that were affected by Europris establishments as treatment stores and to grocery stores that were unaffected as control stores. We know the distance to the closest Europris store for all the grocery stores in our data set in every week of our sample period. This implies that regardless of whether we look at relocations or new entries, we always consider a change from a given pre-distance. Hence, the estimated effect of a relocation and a new entry will be parallel, and we do not need to distinguish between these when evaluating the results. From now on, we will refer to both of them as establishments. Furthermore, while some of the treated grocery stores ended up with a Europris store next door after an establishment, other treatment stores remained some distance away. This allows us to break down the effect of a Europris establishment by distance bins and to explore how the effect of having a discount variety store close by depends on the distance between the stores. The underlying assumption that allows us to interpret our results causally is that the underlying trend in the grocery store sales is not dependent on treatment status. We provide visual support for this common trend assumption and show a Granger causality test in the Robustness section (section 2.4.3).

Since both the grocery chain and Europris have national pricing strategies, it is very unlikely that prices in local grocery stores are affected by the distance to the closest Europris store.[5] We are therefore confident that any effects of a Europris establishment will manifest themselves through changes in the sales volume and store visits in the grocery store (rather than in changes in prices).

A central distinction in our analysis is between one-stop and two-stop shopping. In some places, the grocery store and Europris are located close enough to one another for customers to reach both stores from the same parking area. We define one-stop shopping locations as those where the distance between the stores is 250 meters or less. In some of our analyses we lump together all cases where the distance is above 250 meters as two-stop locations, while in other analyses we break down the two-stop locations into distance bins.

[5] Meile (2020) studies the price setting of Norwegian grocery retail chains empirically, and finds that the grocery chain we consider follows a national, uniform pricing strategy. Uniform national pricing is also confirmed in Friberg, Steen and Ulsaker (2021). Regarding Europris, we look at the information on the chain's website. We find that the online prices (which at least apply to home delivery and in-store pickup) do not differ across stores and that weekly ads apply throughout the chain, suggesting that prices are decided centrally.

2.3 Data and a first look at the market

2.3.1 Data

We combine data from several sources. The main data set used in our analyses is sales data received from the grocery chain. We have weekly sales data at the store-category level as well as weekly store visits. We have data from all product categories, which implies that we can both look at total weekly sales at the store level and separate out sales for products that are also sold at Europris. The sample period is from 11 January 2016 to 22 December 2019.

The next step is to compile geographical location data. We obtained data on the address, opening date and closing date (where applicable) of all Europris stores in Norway directly from the chain (Europris, 2020). The data was received on 11 February 2019.[6] The sales data from the grocery chain also contains information about the grocery stores' addresses. The exact locations of the Europris and grocery stores were obtained through Google Maps Platform's Geocoding API.[7]

For a given grocery store in a given week, we want to find the distance and driving duration to the closest Europris store. To calculate distance and duration, we use the routing service of the Norwegian Public Roads Administration (NPRA).[8] For each grocery store and each week, we then use the distance and duration of the closest Europris store that was open in the week in question.

We include a number of additional control variables in our regressions. Statistics Norway publishes yearly municipality level data on persons and land area, as well as median after tax income and the percentage of the population with higher education ssbPopArea, ssbInc, ssbEduc. From the grocery chain, we obtained a data set with yearly information about all grocery stores in Norway (from all chains), including information about revenue at the store level. This data set was used to calculate the Herfindahl-Hirschman Index (HHI) at the municipality level, using market shares both at the store level and at the chain level.

[6] With updates on 2 July 2019 and 15 May 2020.

[7] See https://developers.google.com/maps/documentation/geocoding/overview for documentation of this service. The locations were obtained on 15 October 2020.

[8] See https://labs.vegdata.no/ruteplandoc/ for documentation of this routing service. The routing service was accessed on 15 October 2020, which means that all duration and distances were calculated with the road network that applied on that date.

2.3.2 A first look at the market

Discount variety retail in Norway

Among discount variety retailers in Norway, Europris is the largest with a market share of about 30%.[9] Since its foundation in 1992, both revenues and the number of stores have grown steadily, reaching more than six billion NOK in revenue and 264 stores in 2019. While the compound annual grown rate for total retail was about 3% for 2012-2017, variety retail grew almost twice as fast, suggesting that with overlapping product ranges grocery chains were loosing market shares to variety retail (Europris ASA capital markets day presentation 2018). Few other retail segments than discount variety retailers can look back at a similar increase in revenues in recent years. Table 2.1 and table 2.2 show the growth in Europris revenues and the number of store establishments and relocations in the years we consider (Europris ASA annual report 2017; Europris ASA annual report 2019).

Table 2.1: Europris growth rate 2016-2019

	2016	2017	2018	2019
Growth in Revenues	9.8%	6.6%	7.3%	7.2%

Table 2.2: Europris establishments and relocations 2016-2019

	2016	2017	2018	2019
New stores	11	11	9	6
Relocated stores	11	7	8	6

According to the latest Shopper Trend report (Nielsen 2020), more than 50% of the respondents answered that they had bought groceries from a discount variety retailer within the last six months, and the store most frequently visited was Europris.

A comparison of the assortment in Europris and the grocery chain shows that the extent of product overlap is large: as much as 35% of the grocery chain's product categories are also sold in Europris stores, and these product categories amount to 25% of the grocery chain's turnover.[10]

[9]The first and second runners-up, Biltema and Clas Ohlson have approximately 20% and 15% respectively.

[10]To find the product overlap, we first looked up all the product categories that Europris offers online

The Norwegian producers are more concentrated as compared to producers in other grocery markets e.g., Sweden. This, together with particular high tariff-barriers has led to very strong national brands, and though increasing, private labels have a relatively low share in the Norwegian grocery market. This implies that the same products are often found in different stores - even across grocery chains. This is indeed also the case for many of the products that are sold by both Europris and the grocery chain.

The grocery stores

Our data sample consists of 190 distinct grocery stores. The stores are distributed all over Norway, but only stores located in municipalities where Europris establishments or relocations took place during our sample period place are included. Because retail competition is likely to function differently in city centres than in suburban and rural areas, we drop observations in the municipalities of Oslo, Bergen city center and Trondheim city center. In the main analysis, we also disregard stores in the vicinity of Europris entries but where it is unclear whether the distance to the closest Europris store was reduced or not after entry.[11] The number of active grocery stores in a given week ranges from 149 to 180. Figure 2.1 below shows the distribution of the stores by distance to the closest Europris store in the first and last sample week.

(such as detergent, filter coffee, and pick-and-mix candy). We then compared this to the data set we obtained from the grocery chain, which includes information about product categories.

[11] In some cases, whether or not entry reduces the distance between the grocery store and the closest Europris store depends on the direction of travel or the exact route chosen. In appendix A.3 we include the model outcomes when these additional 16 stores are included

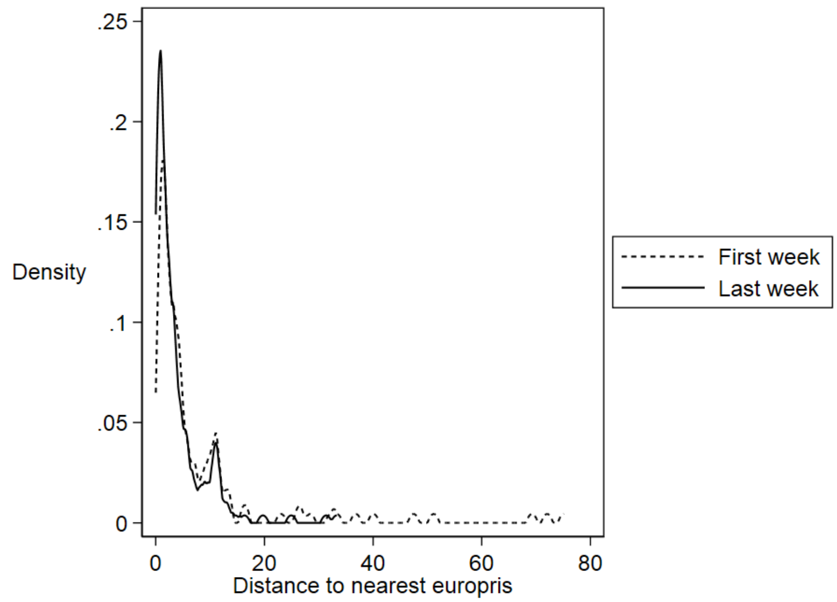


Figure 2.1: Density of grocery stores over distance to closest Europris store

Most of the grocery stores are located within a few kilometers of a Europris store, and the distribution shifts slightly to the left over the period we consider. In the first week, 134 out of 149 grocery stores are closer than 15 km to Europris. In the last week, the same is true for 175 out of 180 stores. The summary statistics in Table 2.3 provide closer details.

Table 2.3: Summary statistics

	Count	Mean	Sd	Min	Max	p25	p50	p75
Distance	34228	5.69	10.02	0.00	75.11	1.08	2.71	6.09

The average distance from a grocery store to the closest Europris is 5.69 km. The shortest distance is 0.0 km, while the longest distance is about 75 km.

The main variables of interest are activity indicators: sales and store traffic.[12] Table 2.4 shows the average store activity across all grocery stores in the data set.

Table 2.4: Average store activity

	Weekly sales	Store traffic
All stores	1 232 886	5503.63

[12]Store traffic, as measured by the number of receipts, refers to the number of customers visiting per week.

Distance categories

As we argued above, the effect of establishment may depend on the distance between the stores. Hence, we define the following distance categories:

Table 2.5: Distance categories

	Distance bin	Binary category
Same parking	1	One stop
250m-2km	2	Two stops
2km-5km	3	Two stops
5km-15km	4	Two stops
More than 15km	5	Two stops

The grocery stores in category 1 are located within 250 meters from a Europris store, which we define as close enough for the customers to visit both the grocery store and Europris in one stop. Table 2.6 below shows store activity by distance categories.

Table 2.6: Average store activity by distance category

	Weekly sales	Store traffic	Number of stores
Same parking	1 341 951	5613.08	6
250m-2km	1 275 654	5980.73	67
2km-5km	1 265 425	5516.03	59
5km-15km	1 157 070	5176.06	45
More than 15km	1 076 884	4071.88	13

The grocery stores that can be reached from the same parking area as a Europris store have the highest weekly sales and second highest store traffic, while the stores with the longest distance to a Europris store have the lowest turnover and store traffic. Overall, however, the differences are not large between the groups.

The store composition: Control and treatment groups

For descriptive purposes, we consider the 142 stores that are never affected as control stores and the 48 stores that at some point become affected as treatment stores.[13] Table 2.7 and Table 2.8 summarize the distance statistics by treatment status.

[13] Table 2.1 in Appendix A.1 shows the number of stores by treatment status and distance category.

Table 2.7: Summary statistics for control group

	Count	Mean	Sd	Min	Max	p25	p50	p75
Distance	24738	4.43	4.76	0	40.07	1.30	2.96	6.04

Table 2.8: Summary statistics for treatment group

	Count	Mean	Sd	Min	Max	p25	p50	p75
Pre-distance	9490	15.66	19.67	0.41	75.11	3.03	5.67	23.05
Post-distance	9490	3.11	6.32	0.00	31.37	0.31	1.01	2.20
Change	9490	12.55	17.87	0.34	71.76	1.95	3.61	13.18

The average distance to Europris in the control group is 4.4 km, the shortest distance is 0.0 km and the longest distance is 40.1 km. 75% of the stores in the control group are located less than 6.0 km from a Europris store, 50% less than 3.0 km and 25% less than 1.3 km.

Compared to the control group stores that have an average distance to the closest Europris store of 4.4 km, the treatment stores were on average less exposed to Europris prior to the establishments (15.7 km), but are on average more exposed to Europris in the post-period (3.1 km).

Looking at the change within the treatment group, the relocations and new establishments led to an average change of approximately 12.6 km. In the pre-period, 50% of the grocery stores were located less than 5.7 km from a Europris store, and 25% were located less than 3.0 km away. In the post-period, 50% are located less than 1.0 km from Europris and 25% less than 310 meters. This shift is illustrated in Figure 2.2 below:

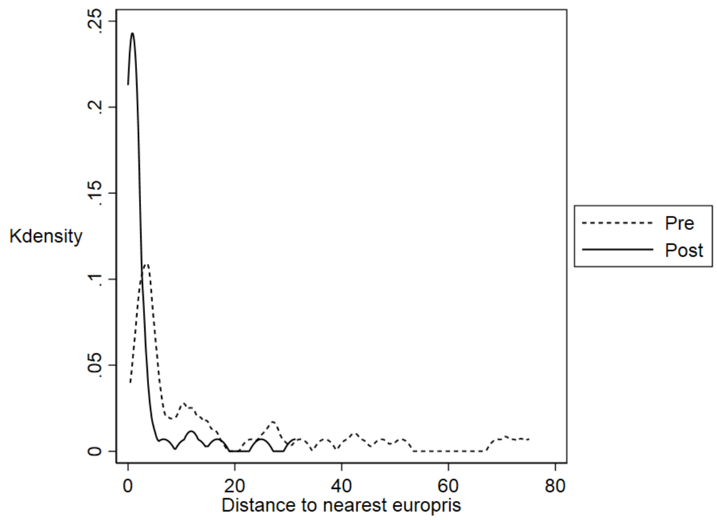


Figure 2.2: Density of grocery stores in the treatment group over distance

In the first week, 30 treatment stores are closer than 15 km from Europris and 12 stores are further away. In the last week, 46 out of 48 treatment stores are located within 15 km from Europris. Tables 2.9 and 2.10 below present the store activity measures by treatment status and whether the established Europris stores can be visited from the same parking area as the grocery stores in the post-period.

Store activity by treatment status

As many as 25% of our grocery stores ended up with a Europris store much closer than previously. As we saw from Figure 2.2 the shift was significant for most stores. To which extent does this shift result in a change in the activity level? Below in Tables 2.9 and 2.10, we scrutinize the change in two measures of activity level.

Table 2.9: Average weekly sales

	Pre establishment	Post establishment	Overall	Change
Control	-	-	1 196 403	-
One stop	1 381 962	1 622 909	1 546 380	17.44 %
Two stops	1 189 723	1 302 516	1 264 461	9.48 %

Table 2.10: Average weekly store traffic

	Pre establishment	Post establishment	Overall	Change
Control	-	-	5508.14	-
One stop	6015.57	6552.26	6350.64	8.92 %
Two stops	4975.26	5130.27	5170.74	3.12 %

We find that for both measures, activity increases after the change. There is also a distinct pattern where the effect is between two and three times higher for the one-stop establishments, as compared to cases where customers need to drive between the two stores. However, these figures represent only a before-after effect. Obviously this change might be correlated with market growth stemming from other sources. The table also provides control group averages, and in the next section we will use a diff-in-diff approach where we use the activity development in the 142 non-affected stores as a control for general market growth. Note that we also account for the latter group's distance to the closest Europris stores and store heterogeneity through store fixed effects.

In Tables 2.2 and 2.3 in Appendix A.2, we show sales and store traffic by treatment status and post-period distance categories. We observe that generally, the effect from a new establishment falls with distance. For weekly store traffic we even see negative numbers for the 2-5 km bin, or basically no effect (0.93%) for the corresponding bin for weekly sales.

2.4 A diff-in-diff analysis of co-location effects

The descriptive analysis above suggested that the arrival of a new discount variety store close by affects the activity level of the grocery stores. In fact, to the extent that we could see some clear patterns, co-location – and, in particular, co-location allowing for one-stop shopping – increased the incumbent grocery stores' traffic and sales. Regarding the effect of vicinity in terms of distance when customers need to drive between the stores, the descriptive evidence of an increase in grocery store activity is weaker. Now, we investigate these effects econometrically, where we control both for the development in these measures over time in other grocery stores not affected by establishments, and for the competitive environment faced by the different stores and the demographics of the area.

2.4.1 Diff-in-diff analysis disregarding product heterogeneity

Our diff-in-diff model includes several control variables for local competition and local demographics. We estimate the following generic model:

$$ln(y_{it}) = \alpha_i + \lambda_t + \eta \underline{X}_{it} + \beta D_{it} + \epsilon_{it}$$

Where y is a measure of activity, either weekly sales or store traffic. Subscript i, refers to store, and t refers to week. The matrix X_{it} consists of several local controls: Municipality Herfindal-Hirchman indices on grocery store level, grocery chain level and grocery chain-umbrella level to control for local and national competition. Demographics are included through inhabitants per square kilometer, inhabitants per store and the share of higher education in the municipality. All controls are changing annually and by municipality. We include fixed effects for store (α_i) and week-year (λ_t), and we allow for clustered standard errors on the store level.

Our diff-in-diff parameter is β, which measures the effect of the change in distance to the closest Europris store for the stores in the treatment group. D_{it} is thus our treatment variable that for store i in the treatment group takes the value 0 prior to the Europris establishment, and 1 after.

In Table 2.11 we estimate the overall effect of a reduction in distance to Europris on the grocery store for the two activity measures:

Table 2.11: Effect of establishment

	Log weekly sales	Log weekly store traffic
Establishment	-0.00428	-0.0125
	(0.0207)	(0.0179)
Store FE	✓	✓
Week-year FE	✓	✓
Control variables	✓	✓
N	32328	32328
r2	0.835	0.839

Clustered (store level) standard errors in parentheses
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Using this overall approach, we find no significant effects of the new arrivals of Europris stores. However, this is an overall average effect that combines the effects from both nearby establishments and more distant ones. As we argued above and later show in a simple theoretical model, there are reasons to believe that the sign of the effect may depend on the distance between the grocery store and the newly established Europris store. We could then fail to find an overall effect even if there are actually significant effects for the different co-location distance bins. Hence, we next differentiate the treatment effect into bins for different co-location distances, and extend the model to allow for more treatment dummy variables:

$$ln(y_{ti}) = \alpha_i + \lambda_t + \eta \underline{X}_{it} + \sum_b \beta_b D_{itb} + \epsilon_{it}$$

Now, each β_b refers to a separate distance bin. We start by differentiating between one-stop and two-stop shopping: Comparing our distance bin 1 to distance bins 2 to 5 (as defined in Table 2.5). In Table 2.12 we show the results:

Table 2.12: Effect of establishment by distance

	Log weekly sales	Log weekly store traffic
One stop	0.0986**	0.0618
	(0.0487)	(0.0405)
Two stops	-0.0390**	-0.0377**
	(0.0189)	(0.0176)
Store FE	✓	✓
Week-year FE	✓	✓
Control variables	✓	✓
N	32328	32328
r2	0.836	0.840

Clustered (store level) standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

In line with the descriptive figures above in Tables 2.9 and 2.10, we now obtain a very clear result. For both activity measures we find that one-stop co-location increases the grocery stores' turnover and store traffic in the range of 6% to 10%. The results reported in Table 2.12 suggest that the net effect of establishment is negative for the grocery stores where one-stop shopping is not possible. This applies to both sales and traffic, considering the reduced activity in the order of -4%. Thus, when accounting for underlying time trends using a control group and when including control variables, the apparent positive effect observed in Tables 2.9 and 2.10 only holds for grocery stores where one-stop shopping becomes possible after the establishment of a Europris store. For the other grocery stores, the estimated effect is negative.

That co-location can be beneficial to the incumbent grocery store is in line with most of the models looking at one-stop shopping. The positive effect found for establishments that allow for one-stop shopping suggests that the net effect of the positive agglomeration effect (what we refer to as the extensive margin) and the negative competition effect (what we refer to as the intensive margin) is positive for these stores. We expect that both effects are present also when two stops are required to visit both a grocery store and a Europris store, but that their relative magnitude may depend on the distance between the stores. Our next step is therefore to differentiate the treatment effects even further, allowing for different distance bins for the "two-stop-shopping" group of stores. Now we estimate separate effects for all our five distance bins. The results are shown in Table 2.13.

Table 2.13: Effect of establishment by distance

	Log weekly sales	Log weekly store traffic
Same parking	0.0986**	0.0619
	(0.0487)	(0.0405)
0.25km - 2km	-0.0296	-0.0276
	(0.0254)	(0.0232)
2km-5km	-0.0808***	-0.0849***
	(0.0193)	(0.0244)
5km-15km	-0.0330*	-0.0273
	(0.0199)	(0.0237)
More than 15km	-0.0170	-0.0120
	(0.0154)	(0.0243)
Store FE	✓	✓
Week-year FE	✓	✓
Control variables	✓	✓
N	32328	32328
r2	0.836	0.840

Clustered (store level) standard errors in parentheses
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Now an interesting pattern emerges. The effect of an establishment is positive when the stores can be reached from the same parking area. When the stores are between 250 meters and two km apart, there is no statistically significant effect. When the distance between the stores is between two and five km, an establishment reduces sales by 8%. When the distance is even larger, the effect diminishes and becomes statistically insignificant for stores where the distance is more than 15 km. Figure 2.3 illustrates how the effects on grocery weekly sales and traffic vary with distance to the new Europris store. We observe that both activity measures have an S-shaped pattern.

Figure 2.3: Illustration of estimated S-shape

2.4.2 Diff-in-diff analysis accounting for product heterogeneity

Clearly, we would anticipate to observe heterogeneous effects of Europris establishments depending on whether we look at competing or non-competing product categories. We now estimate our model where we allow the treatment effect to depend on the product type. Hence, we include product interactions in our model:

$$ln(y_{ti}) = \alpha_i + \lambda_t + \eta \underline{X}_{it} + \sum_b \beta_b D_{itb} + \sum_b \beta_b^s D_{itb} Comp_i + \epsilon_{it}$$

As before, each β_b refers to separate distance bins, but now we estimate separate effects for all bins for competing product categories (sold by both chains) and non-competing product categories (only sold by the grocery chain).[14] To do so we include separate inter-

[14]The grocery store data has information about category sales at different levels of aggregation. We

actions for each bin, where the indicator $Comp_i$ takes the value 1 for products in categories that are sold by both chains. This allows us to identify separate effects across product groups as measured by the β_b^s. In Table 2.14 we show the results.

consider an intermediate level of aggregation, which refers to categories such as ketchup, chocolate bars and detergents.

Table 2.14: Effect of establishment by product heterogeneity and distance category (rows 11-15 are gross estimates for the competing product categories calculated from the estimated parameters in the model)

	Log weekly sales
Non-competing, same parking	0.105**
	(0.0480)
Non-competing, 250m-2km	-0.0228
	(0.0257)
Non-competing, 2km-5km	-0.0738***
	(0.0185)
Non-competing, 5km-15km	-0.0330
	(0.0214)
Non-competing, More than 15km	-0.0133
	(0.0155)
Difference competing, same parking	-0.0241**
	(0.00937)
Difference competing, 250m-2km	-0.0263***
	(0.00661)
Difference competing, 2km-5km	-0.0275***
	(0.0101)
Difference competing, 5km-15km	0.000863
	(0.00623)
Difference competing, More than 15km	-0.0115***
	(0.00189)
Competing, same parking	0.0811
	(0.0516)
Competing, 250m-2km	-0.0492*
	(0.0253)
Competing, 2km-5km	-0.101***
	(0.0233)
Competing, 5km-15km	-0.0322**
	(0.0164)
Competing, more than 15km	-0.0249
	(0.0155)
Store FE	✓
Week-year FE	✓
Control variables	✓
N	64656
r2	0.952

Clustered (by stores) standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

In rows 11 to 15 in Table 2.14, we also calculate the gross effects for the competing product categories and their respective standard errors.[15]

Separating competing and non-competing product categories, we find a similar pattern as we did for all products overall: One-stop shopping increases the activity level, suggesting that the extensive margin dominates. For other distance bins, the estimates are negative, suggesting that the competition effect prevails if the stores cannot be reached from the same parking area. The interaction-term-treatment parameters (β_b^s) are negative and significant for most of the bins, indicating that the competing products are more prone to competition from the Europris stores. For instance, in the groups that have a new Eurpris store two to five km away, the competition effect increases from -7.4% to -10.1%, a difference of 2.7 percentage points that is also highly significant. Additionally, we now find a negative and significant parameter for the competing product categories for the distance bin '250m-2km' which is both bigger (-4.9%) and now significant, as opposed to what we found above for all products. This is what we would intuitively anticipate: competition over products that are offered by both the incumbent grocery store and the entering discount variety store is expected to be higher.

Interestingly, the gross effect for one-stop shopping for the competing product categories is not significant (though with a p-value equal to 0.116). On the other hand, the difference parameter β_b^s for the 'same parking' bin is only significant at a 5% level. Hence, in terms of significance it is not obvious that the effect of co-location with common parking is much different across the product groups. Actually, on a 1% level the models conclude that the effect is the same for the two product groups.

In Figure 2.4 we illustrate how the effects on grocery weekly sales vary with distance to the new Europris store for competing and non-competing product categories separately. We observe an S-shaped pattern similar to the overall outcome (Figure 2.3).

[15]The estimates for the competing products categories are simply the sum of the interaction-term-treatment parameters β_b^s and the treatment parameters β_b.

Figure 2.4: Illustration of estimated S-shape for competing and non-competing product categories, (circles and diamonds illustrate significant estimates)

In Table 2.14, we look at all competing and non-competing product categories. To explore the individual effects for some particularly relevant categories, we estimate the model for product categories where the grocery chain and Europris clearly compete, and for product categories where there is no competition. First, we estimate the effect for candy, coffee and detergent, categories that are known to be important in the Europris product portfolio, and where a number of strong national brands suggest that the products sold in Europris and the grocery chain really do compete. The results are reported in Table 2.15 below.

Table 2.15: Log weekly sales

	Candy	Coffee	Detergent
Same parking	0.0384	0.0840*	0.0575
	(0.0963)	(0.0500)	(0.0641)
0.25km - 2km	-0.158***	-0.00233	-0.124***
	(0.0438)	(0.0318)	(0.0332)
2km-5km	-0.198***	-0.115***	-0.181***
	(0.0608)	(0.0248)	(0.0358)
5km-15km	-0.177***	-0.0994**	-0.159***
	(0.0497)	(0.0441)	(0.0500)
More than 15km	0.127***	-0.0535**	-0.0982**
	(0.0339)	(0.0258)	(0.0443)
Store FE	✓	✓	✓
Week-year FE	✓	✓	✓
Control variables	✓	✓	✓
Control income	✓	✓	✓
N	32236	32298	32325
r2	0.817	0.636	0.833

Clustered (store level) standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

We still find a positive agglomeration effect for same-parking establishments, though only weakly significant for coffee. More noteworthy, we find much stronger competition effects. Already for establishments as close as 0.25-2 km, we see strong competition effects and for the second category (2-5 km), the competition effects are strong (between minus 12-20%) and significant for all three product groups. Turning now to product groups that are not sold in Europris stores, we estimate the effect for bread, fresh chicken and milk, and present the results in Table 2.16.

Table 2.16: Log weekly sales

	Bread	Fresh chicken	Milk
Same parking	0.103**	0.139**	0.118**
	(0.0499)	(0.0647)	(0.0544)
0.25km - 2km	-0.0229	-0.0267	-0.0159
	(0.0246)	(0.0361)	(0.0284)
2km-5km	-0.0837***	-0.0451*	-0.0891***
	(0.0281)	(0.0268)	(0.0217)
5km-15km	-0.0111	-0.0426	-0.0131
	(0.0274)	(0.0344)	(0.0102)
More than 15km	-0.0434	0.0120	0.00308
	(0.0488)	(0.0311)	(0.0161)
Store FE	✓	✓	✓
Week-year FE	✓	✓	✓
Control variables	✓	✓	✓
Control income	✓	✓	✓
N	32325	32322	32325
r2	0.882	0.859	0.878

Clustered (store level) standard errors in parentheses
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

The results from the overall regression in Table 2.14 are enhanced, the local agglomeration effect now varies between 10 and 14%, as compared to 9% for the overall effect for non-competing product categories in Table 2.14, but we still see evidence of a competition effect from establishments further away.

2.4.3 Robustness

We perform two different exercises to make sure that our results are not biased by underlying dynamics in the treatment and control groups.

First, we take a closer look at how sales evolve over time in the treatment and control stores prior to the treatment taking place. We plot average monthly sales in Figure 2.5.

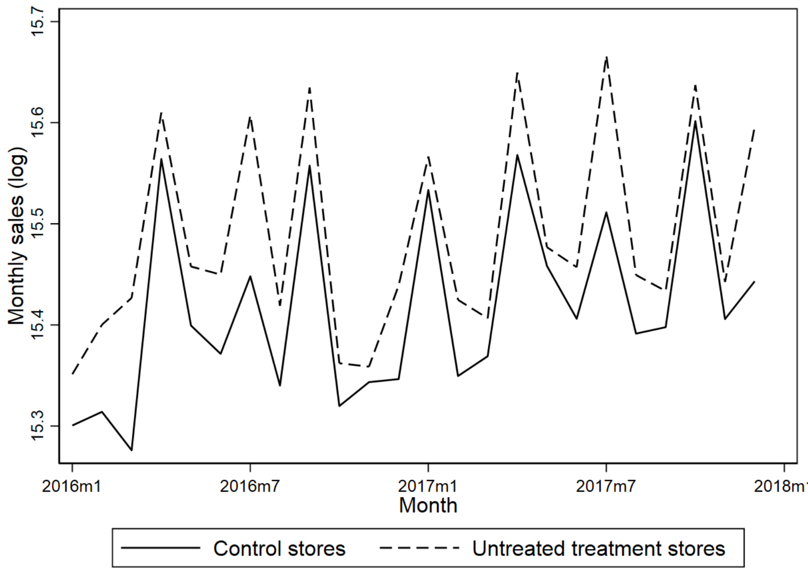


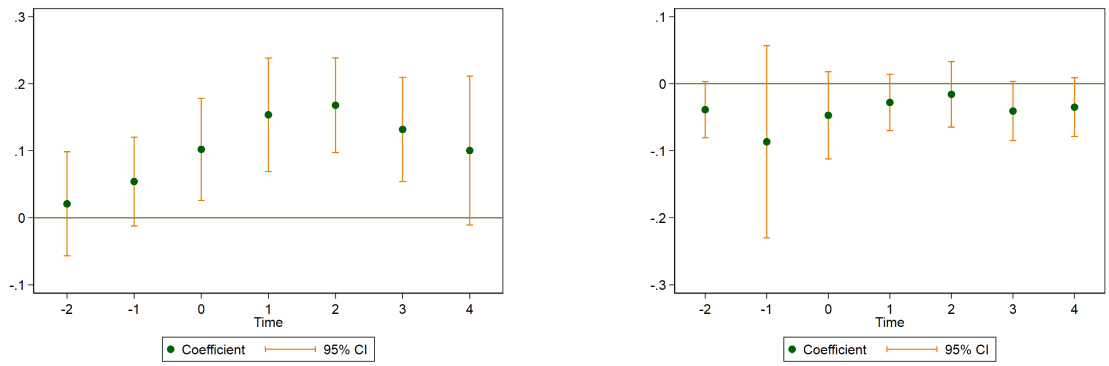
Figure 2.5: Pre-trends in sales

The dashed line represents the average monthly sales in stores that never receive treatment, while the solid line shows the average monthly sales in treatment stores that have not yet received treatment. The trends in sales in the two groups share dynamics, suggesting that the activity changes in the control and treatment groups have a common trend.

Second, since treatments occur at different times for different stores we choose to also perform a Granger causality test. Following the approach used by Author (2003), we now estimate:

$$ln(y_{ti}) = \alpha_i + \lambda_t + \eta \underline{X}_{it} + \sum_{\tau=-2}^{-1} \varphi_\tau D_i 1(t - T_i^* = \tau) + \sum_{\tau=0}^{4} \phi_\tau D_i 1(t - T_i^* = \tau) + \epsilon_{it}$$

The binary indicator D_i equals *one* if a store received treatment during the period we consider. We interact D_i with event-time dummies, $1(t - T_i^* = \tau)$. The dummies take on the value *one* when the time of observation (t) is $\tau \in [-2, 4]$ months from the treatment month (T_i^*). Earlier pre-months ($t - T_i^* \leq -2$) serve as baseline. Observations more than four months after a treatment are included through the dummy $1(t - T_i^* \geq 4)$. The coefficients on leads and lags of establishment are represented by φ_τ and ϕ_τ respectively. If it is indeed the case that entries affect store activity, and not the other way around, we expect non-significant leads and significant lags. The results of the estimation are plotted below in Figure 2.6.



(a) One stop *(b) Two stops*

Figure 2.6: Event study

Neither the one-stop results (Panel a) nor the two-stop results (Panel b) show significant leads. This suggests that there are no anticipatory effects of establishments. In Panel a, we notice a much higher and significant estimate in the month of establishment, which is also sustained in the subsequent months. The lags provide evidence of increased store activity in the post-periods. In Panel b, the lags are insignificant. Considering that we found no significant treatment effect for half of the distance bins within two stops, this is not surprising. Overall, the panels are consistent with what we observe in our econometric analysis.

We undertake two additional sets of robustness tests. First we include stores that have Europris entries in the vicinity but where it is unclear whether the entries reduce the distance to the closest Europris store (refer Footnote 11). The results are presented in Appendix A.3, Tables 2.4, 2.5 and 2.6. Next, we re-estimate the models excluding our control variables. These results are presented in Appendix A.4, Tables 2.7, 2.8 and 2.9. Generally we get the same results for the whole set of models. There are some marginal changes in significance levels but, generally, all our results are robust to these alternative specifications and data sets.

2.5 Extensive- and intensive margins: How to understand co-location forces

2.5.1 A simple theory model

In the empirical analysis we find that whether the grocery store ends up being better or worse off upon Europis' entry depends on the distance between the two stores. We also find a clear S-shaped pattern. The effect ultimately depends on the distance between the two stores. If Europris ends up sufficiently close, the grocery store tends to benefit. In contrast, an establishment that does not bring Europris close enough appears to be harmful. We attribute these findings to the interplay between the extensive margin (increased localized demand) and the intensive margin (fiercer competition and reduced purchases by existing customers). In this section, we develop a simple theoretical example that shows how decomposing the effect into an extensive and an intensive margin provides an intuitive explanation of the results.

Suppose that the market is represented by a line that starts at 0 and ends at an indefinite point. the grocery store is located at $x_G = 0$. It sells n products at a common price p. The customers are uniformly distributed at discrete intervals along the line. They value store proximity, and face travel costs (t) that increase in distance to the grocery store. Hence, the utility a customer located at x obtains from shopping at the grocery store is given by

$$u_G = nv - tx - np$$

Where v is the customer's gross willingness to pay per product. Note that the customers only shop at the grocery store if the utility exceeds their reservation utility u_R [16].

Pre Europris establishment

Consider first a market without a Europris store located close enough to affect the grocery store's demand. The consumer that is indifferent between shopping and not shopping at the grocery store is located at

$$\hat{x} = \frac{nv - np - u_R}{t}.$$

[16] The reservation utility reflects the attractiveness of the customers' outside options, such as rival grocery stores.

The location of the grocery store and the indifferent consumer is illustrated in figure 2.7.

Figure 2.7: Pre establishment

The figure also shows that the grocery store's demand before a Europris establishment is given by

$$D_G = \hat{x} = \frac{nv - np - u_R}{t}.$$

Post Europris establishment

Suppose then that Europris establishes a store at $x_E \in [0, \hat{x}]$. Europris offers one of the products sold by the grocery store, but at a lower price αp, where $\alpha \in (0, 1)$. The utility of just shopping at the grocery store is unchanged, but the customers might obtain an additional value by purchasing the cheaper product from Europris. Visiting both stores provides a utility equal to

$$u_{E,G} = nv - (n-1)p - \alpha p - tx - t(x_E - x) - F$$

for customers located at $x \in (0, x_E)$, and

$$u_{E,G} = nv - (n-1)p - \alpha p - tx - F$$

for customers located at $x > x_E$ [17]. The parameter F denotes the additional cost that customers face if the stores cannot be visited in one stop, i.e., unless $x_E \leq 250$m. We find that the location of the consumer that is indifferent between just shopping at the grocery store and shopping at both the grocery store and Europris is given by

$$\tilde{x} = x_E - \frac{p(1-\alpha) - F}{t}.$$

[17]These customers pass Europris on their way to the grocery store and no extra travel costs occur. We assume that the customers do not care where on the way Europris is located, only about whether they have to stop once or twice.

The shorter the distance between the grocery store and Europris, the more customers prefer joint shopping. The customer that is indifferent between shopping at both stores and none of them is located at

$$\hat{x}' = \frac{nv - p(n-1) - \alpha p - u_R - F}{t}.$$

Consequently, customers that only shop at the grocery store are located to the left of $\tilde{x}$, while customers who shop at both stores are located between $\hat{x}'$ and $\tilde{x}$. Figure 2.8 outlines the grocery store's exclusive demand (D_G) and shared demand ($D_{E,G}$).

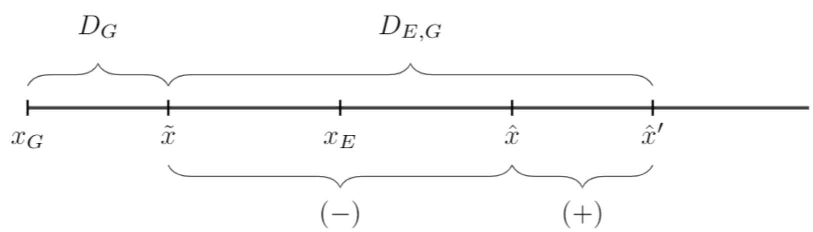


Figure 2.8: Post establishment

The extensive margin

For customers to the right of x_E, the presence of Europris increases the utility of travelling to the left on the line. As a result, some of the customers that previously did not shop at the grocery store change their mind now that they can visit Europris during the same trip. This effect is what we refer to as *the extensive margin* in response to a Europris establishment. Graphically, the extensive margin is captured by $\hat{x}'$ being located further to the right than $\hat{x}$. New grocery store customers are given by

$$\hat{x}' - \hat{x} = \frac{1}{t}(p(1-\alpha) - F)$$

Since the new customers purchase $(n-1)$ products from the grocery store and 1 product from Europris, the increase in the grocery store's revenue equals

$$(\hat{x}' - \hat{x})p(n-1)$$

The intensive margin

After the Europris establishment, some of the customers who previously purchased all n products from the grocery store decide to purchase the discounted product from Europris. This response to the increased competition is called *the intensive margin*. For the grocery store this effect is always negative as it implies lower demand. A comparison of figure 2.7 and figure 2.8 shows how the customers located between $\hat{x}$ and $\tilde{x}$ went from being exclusive grocery store customers to becoming shared customers in the wake of the establishment. Formally, we have that

$$\hat{x} - \tilde{x} = \frac{nv - u_R - p(n-1) - \alpha p - F}{t} - x_E$$

customers purchase less at the grocery store. This corresponds to a revenue loss equal to

$$(\hat{x} - \tilde{x})p$$

The total effect is simply the sum of the gained revenues due to the extensive margin and the lost revenues due to the intensive margin.

2.5.2 Numerical illustration of the co-location forces

Figure 2.9 graphs the effect of a Europris establishment on the grocery store revenues. It shows the effects from the extensive margin, the intensive margin and the total. The parameter values are set to $v = 1$, $t = 2$, $\alpha = 0.5$, $n = 10$, $p = 0.75$, $u_R = 0,1$ and $F = 0.33$.

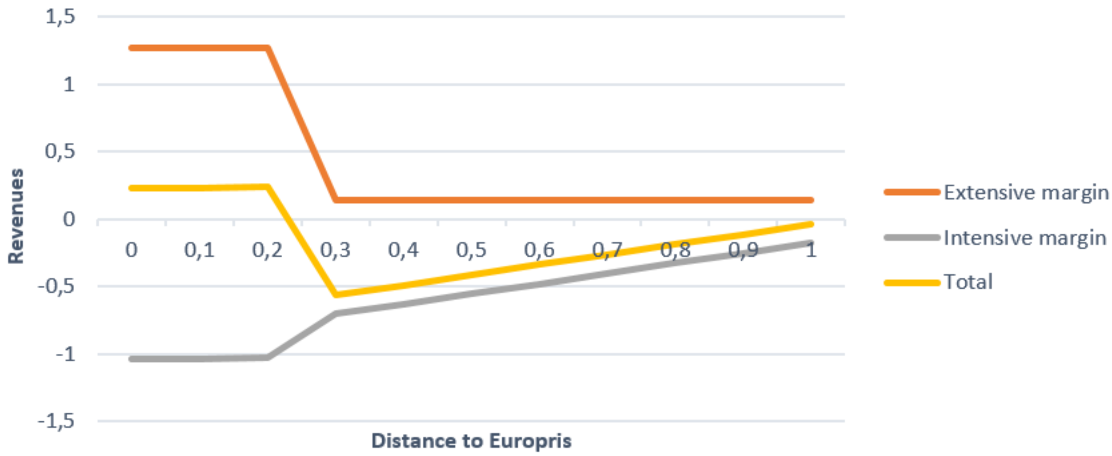


Figure 2.9: Intensive vs extensive margin

Notice that the effect of the extensive margin is dominating when the distance between Europris and the grocery store is short. There are two main reasons for this. First, the customers do not have to make an additional stop to visit Europris, which attracts more customers. Second, the gain from attracting a new customers is greater than the loss from an exclusive customer turning into a shared customer. Recall that new customers purchase $(n-1)$ products, while shared customers only purchase one product less than before the Europris establishment. However, as the distance between the grocery store and Europris increases, the effect of the intensive margin becomes dominant. When shopping at both stores requires two stops, a Europris establishment might not attract sufficiently many customers for the grocery store to benefit from it. Eventually, the competition effect also fades out and the total effect approaches zero.

While the predictions from our modelling framework will be sensitive to the parameters chosen, we do find in Figure 2.9 a very similar pattern to the S-shape observed in our empirical analysis, as illustrated in, e.g., Figure 2.3. The observed and estimated S-shape is thus consistent with a simple theoretical framework.

2.6 Conclusion

We analyze a number of entries and relocations by the Norwegian discount variety chain Europris during the period 2016 to 2019. We measure how location choices affect local grocery stores' sales and traffic, using a diff-in-diff strategy and data from a large Norwegian grocery chain. We combine detailed data on travelling distance between new entries/relocations and local grocery stores and data on local grocery store activity to measure the entry effects. The granularity of the data enables us to estimate separate effects for competing and non-competing product categories.

We find significant effects from entries and relocations. Moreover, our findings suggest an S-shaped relationship between distance and store activity; sufficiently close entries increase local demand since more customers are attracted to the market, but as the distance increases the competitive effect of a new discount variety store dominates, and local grocery sales and traffic are reduced. As we move further away, the entry effect is gradually reduced to zero. We show that this empirical finding can be squared with a simple location theory model, showing a similar pattern.

When Europris is not locating very close to the grocery chain we consider, it could possibly locate close to a rival grocery chain. This might obviously increase the rival grocery chain's attractiveness, and thus represent a negative competitive effect for our grocery chain. Since we do not control for the neighbouring stores at Europris' new location in our analysis, this effect would be embedded in the negative competition effect we observe in our data. If Europris locates near a rival, it would increase the value of the rival's location and shift more local demand towards the competing grocery store.

Most of the empirical literature accommodating local competition in retail markets treats local competition as a linear effect: the closer a competitor is located, the fiercer the competition (see e.g., Seim (2006) and Picone et al. (2009)). In line with existing literature, we do find that a competitive effect is present, but our results also suggest that this competition effect is dominated by a local and positive agglomeration effect leading to more demand if the distance between stores stores is short enough. However, the agglomeration effect seems to be very local: as soon as the consumer needs to travel even short distances between the stores, the agglomeration effect wears off and becomes dominated by the negative competition effect.

Our results are clearly supporting some of the insights from theory, like Stahl's (1982) conjectures that depending on product overlap and demand heterogeneity co-location can be positive. Moreover, our findings are in line with what others have found, such as Vitorini (2012) who finds empirical support for firms co-locating despite potential business stealing effects. Picone et al. (2009) find that co-location is more likely if the firms sell differentiated products. However, this does not necessarily imply that co-location requires maximal differentiation. Our results suggest that even a relatively large product overlap is compatible with co-location. We complement existing literature by providing evidence that the net effect of agglomeration forces and competitive pressure depends on the distance between the stores.

Our results also have relevance for the ongoing public discussion on store location policies in several countries. Some countries (e.g., Denmark and Sweden) have imposed local competition regulations regarding new store locations to maximise local competition. Our results seem to support the development of larger areas where several shops can be established (e.g.in malls), sharing joint parking areas rather than regulating areas for single store establishments. The stores can anticipate higher local demand, though they will be exposed to a competitive effect from stores offering competing products. The first effect is obviously positive to the retail firms. The latter effect is not, but it is positive for the consumers.

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Appendix

A.1 Store number by distance category and treatment status

Table 2.1: Number of stores

	Number of stores
Control	142
Same parking	13
250m-2km	23
2km-5km	6
5km-15km	3
More than 15km	3

A.2 Store activity distance bins and treatment status

Table 2.2: Average weekly sales

	Pre establishment	Post establishment	Overall	Change
Control	-	-	1 196 403	-
Same parking	1 381.962	1 622 909	1 546.38	17.44 %
250m-2km	1 247.753	1 402 328	1 343.209	12.39 %
2km-5km	1 227.563	1 239 016	1 251.796	0.93 %
5km-15km	814 134	848 312	842 879	4.20 %
More than 15km	1 044 728	1 118 496	1 107 640	7.06 %

Table 2.3: Average weekly store traffic

	Pre establishment	Post establishment	Overall	Change
Control	-	-	5508.14	-
Same parking	6015.57	6552.26	6350.64	8.92 %
250m-2km	5214.69	5481.83	5490.48	5.12 %
2km-5km	5421.41	5189.43	5382.92	-4.28 %
5km-15km	3636.14	3665.31	3687.39	0.80 %
More than 15km	3586.40	3781.66	3778.39	5.44 %

A.3 Include unclear treatment stores

Table 2.4: Effect of establishment by distance

	Log weekly sales	Log weekly store traffic
One stop	0.0948**	0.0600
	(0.0441)	(0.0367)
Two stops	-0.0446***	-0.0405***
	(0.0165)	(0.0155)
Store FE	✓	✓
Week-year FE	✓	✓
Control variables	✓	✓
N	34835	34835
r2	0.844	0.847

Clustered (by store) standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 2.5: Effect of establishment by distance

	Log weekly sales	Log weekly store traffic
Same parking	0.0951**	0.0604
	(0.0441)	(0.0367)
0.25km - 2km	-0.0228	-0.0195
	(0.0222)	(0.0202)
2km-5km	-0.0861***	-0.0812***
	(0.0170)	(0.0205)
5km-15km	-0.0771**	-0.0718*
	(0.0368)	(0.0391)
More than 15km	-0.0180	-0.0114
	(0.0142)	(0.0225)
Store FE	✓	✓
Week-year FE	✓	✓
Control variables	✓	✓
N	34835	34835
r2	0.845	0.847

Clustered (by store) standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Table 2.6: Effect of establishment by product heterogeneity and distance category (rows 11-15 are gross estimates for the competing product categories calculated from the estimated parameters in the model)

	Log weekly sales
Non-competing, same parking	0.102**
	(0.0434)
Non-competing, 250m-2km	-0.0169
	(0.0224)
Non-competing, 2km-5km	-0.0813***
	(0.0167)
Non-competing, 5km-15km	-0.0772**
	(0.0372)
Non-competing, More than 15km	-0.0142
	(0.0143)
Difference competing, same parking	-0.0252***
	(0.00855)
Difference competing, 250m-2km	-0.0228***
	(0.00616)
Difference competing, 2km-5km	-0.0200**
	(0.00843)
Difference competing, 5km-15km	0.00110
	(0.00419)
Difference competing, More than 15km	-0.0114***
	(0.00183)
Competing, same parking	0.0814*
	(0.0469)
Competing, 250m-2km	-0.0327*
	(0.0184)
Competing, 2km-5km	-0.0648***
	(0.0212)
Competing, 5km-15km	0.0298
	(0.0264)
Competing, more than 15km	-0.0163
	(0.0124)
Store FE	✓
Week-year FE	✓
Control variables	✓
N	69670
r2	0.954

Clustered (by store) standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

A.4 Without control variables

Table 2.7: Effect of establishment by distance

	Log weekly sales	Log weekly store traffic
One stop	0.100**	0.0632
	(0.0474)	(0.0398)
Two stops	-0.0473**	-0.0433**
	(0.0194)	(0.0177)
Store FE	✓	✓
Week-year FE	✓	✓
N	34228	34228
r2	0.838	0.842

Clustered (by store) standard errors in parentheses
* p0¡0.10, ** p<0.05, *** p<0.01

Table 2.8: Effect of establishment by distance

	Log weekly sales	Log weekly store traffic
Same parking	0.100**	0.0633
	(0.0474)	(0.0398)
0.25km - 2km	-0.0390	-0.0345
	(0.0270)	(0.0241)
2km-5km	-0.0830***	-0.0850***
	(0.0192)	(0.0241)
5-15km	-0.0520***	-0.0426***
	(0.0170)	(0.0161)
More than 15km	-0.0179	-0.0105
	(0.0129)	(0.0229)
Store FE	✓	✓
Week-year FE	✓	✓
N	34228	34228
r2	0.838	0.842

Clustered (by store) standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 2.9: Effect of establishment by product heterogeneity and distance category (rows 11-15 are gross estimates for the competing product categories calculated from the estimated parameters in the model)

	Log weekly sales
Non-competing, same parking	0.107**
	(0.0467)
Non-competing, 250m-2km	-0.0327
	(0.0274)
Non-competing, 2km-5km	-0.0762***
	(0.0184)
Non-competing, 5km-15km	-0.0507***
	(0.0180)
Non-competing, More than 15km	-0.0146
	(0.0130)
Difference competing, same parking	-0.0247***
	(0.00945)
Difference competing, 250m-2km	-0.0249***
	(0.00654)
Difference competing, 2km-5km	-0.0270***
	(0.0100)
Difference competing, 5km-15km	-0.00361
	(0.00678)
Difference competing, More than 15km	-0.0110***
	(0.00201)
Competing, same parking	0.0820
	(0.0505)
Competing, 250m-2km	-0.0576**
	(0.0264)
Competing, 2km-5km	-0.103***
	(0.0232)
Competing, 5km-15km	-0.0543***
	(0.0156)
Competing, More than 15km	-0.0255**
	(0.0130)
Store FE	✓
Week-year FE	✓
N	68456
r2	0.953

Clustered (by store) standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

A.5 With income control variable

Table 2.10: Effect of establishment by distance

	Log weekly sales	Log weekly store traffic
One stop	0.104**	0.0636
	(0.0498)	(0.0418)
Two stops	-0.0376*	-0.0372**
	(0.0192)	(0.0178)
Store FE	✓	✓
Week-year FE	✓	✓
Control variables	✓	✓
Control income	✓	✓
N	32328	32328
r2	0.836	0.840

Clustered (store level) standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 2.11: Effect of establishment by distance

	Log weekly sales	Log weekly store traffic
Same parking	0.104**	0.0637
	(0.0499)	(0.0418)
0.25km-2km	-0.0287	-0.0272
	(0.0257)	(0.0233)
2km-5km	-0.0802***	-0.0847***
	(0.0187)	(0.0240)
5km-15km	-0.0234	-0.0238
	(0.0214)	(0.0246)
More than 15km	-0.0203	-0.0132
	(0.0157)	(0.0245)
Store FE	✓	✓
Week-year FE	✓	✓
Control variables	✓	✓
Control income	✓	✓
N	32328	32328
r2	0.836	0.840

Clustered (store level) standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 2.12: Effect of establishment by product heterogeneity and distance category (rows 11-15 are gross estimates for the competing product categories calculated from the estimated parameters in the model)

	Log weekly sales
Non-competing, same parking	0.110**
	(0.0492)
Non-competing, 250m-2km	-0.0219
	(0.0260)
Non-competing, 2km-5km	-0.0732***
	(0.0179)
Non-competing, 5km-15km	-0.0237
	(0.0227)
Non-competing, More than 15km	-0.0165
	(0.0158)
Difference competings, same parking	-0.0241**
	(0.00937)
Difference competing, 250m-2km	-0.0263***
	(0.00661)
Difference competing, 2km-5km	-0.0275***
	(0.0101)
Difference competing, 5km-15km	0.000863
	(0.00623)
Difference competing, More than 15km	-0.0115***
	(0.00189)
Competing, same parking	0.0862
	(0.0528)
Competing, 250m-2km	-0.0482*
	(0.0255)
Competing, 2km-5km	-0.101***
	(0.0227)
Competing, 5km-15km	-0.0228
	(0.0182)
Competing, more than 15km	-0.0280*
	(0.0158)
Store FE	✓
Week-year FE	✓
Control variables	✓
Control income	✓
N	64656
r2	0.953

Clustered (by stores) standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Chapter 3

Size-based input price discrimination under endogenous inside options

Size-based input price discrimination under endogenous inside options*

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Abstract

Individual retailers may choose to invest in a substitute to a dominant supplier's product (inside option) as a way of improving their position towards the supplier. If there are transactional economies of scale, a large retailer has stronger investment incentives than a smaller rival, and may be in a position to obtain a selective rebate (size-based price discrimination). Yet, we often observe that dominant suppliers do not charge small retailers more than large retailers. We argue that the reason for this is that the suppliers could be better off by committing to charge a uniform price and thereby affect the retailers' investment incentives. In this regard, the competitive pressure among the retailers plays a role: The more fiercely the retailers compete, the more each retailer cares about relative input prices. Other things equal, this implies that the retailers will invest more in the substitute the greater the competitive pressure. We show that if the competitive pressure is sufficiently strong, the supplier can profitably incentivize the large retailer to reduce its investments by committing to charge a uniform input price. Finally, we show that under uniform input pricing, the large retailer may induce smaller rivals to exit the market by strategically under-investing in inside options.

Keywords: Input price discrimination, size asymmetries, retail competition, inside options, entry, exit.
JEL classifications: D21, L11, L13.

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3.1 Introduction

Size-based input price discrimination in favor of large retailers is an age-old issue. Walmart's success, for instance, has partly been explained by its size leading to advantageous input prices (see e.g. Basker, 2007; Ellickson, 2016; Dukes, Gal-Or and Srinivasan, 2006); a ten percent increase in volume reduces Walmart's marginal upstream costs by two percent (Basker, 2007). Likewise, Amazon exploits its power as a large retailer to obtain low input prices in the book publishing market (Gilbert, 2015). In the US multi-channel TV market, the per customer input prices for a large firm like Comcast could be 25 percent lower than those faced by smaller firms (Crawford and Yurukoglu, 2012; Doudchenko and Yurukoglu, 2016). The UK competition authorities found a significant negative relationship between size in grocery retailing and unit input prices (Competition Commission, 2008). In 2019, the Norwegian Competition Authority (2019) made a comprehensive study of input prices in the grocery market; from some dominant suppliers, the largest retail chain obtains a selective rebate of more than 15 percent compared to the smaller rivals.[1] These examples indicate that input price discrimination takes place in a large array of industries. The aim of this paper is to shed some new light on why suppliers price discriminate, and to analyze in what situations the supplier might be better off if it could commit not to discriminate.

Suppliers cannot price discriminate unless they have some market power, but it is far from obvious why a supplier with market power should want to let input prices depend on the size of the respective buyer (hereafter labeled retailer). In the public debate, the typical story used to explain size-based input price discrimination is that it is more costly for the supplier to lose a contract with a large retailer than with a small retailer.[2] This strengthens the bargaining position of large retailers. The problem with this story, is that it neglects the fact that it is also more costly for a large than for a small retailer to lose the contract with the supplier. This strengthens the bargaining position of the supplier towards large retailers. Katz (1987) shows that these effects exactly offset each other whenever size is

[1]The Norwegian Competition Authority (2019) confirms that the revealed price discrimination favored the largest chain on the margin, and the competition authority has started an investigation towards the largest chain and two dominant suppliers. Analogously, the investigation of the UK grocery market by the Competition Commission (2008, Appendix 5.3) found that "an increase in the volumes purchased by a retailer or wholesaler is associated with a reduction in both the unit and net price paid."

[2]This claim was given support by Galbraith's concept of countervailing buyer power (Galbraith, 1952). However, Galbraith offers no formal model, and Stigler (1954) was criticizing Galbraith for formulating a dogma rather than a theory. See also von Ungern-Sternberg (1996).

the only difference between the retailers; there will be no price discrimination.[3]

Having established this, Katz (1987) then assumes that large retailers have better access to an alternative source of supply than do small retailers; if this is the case, price discrimination might evolve in favor of large retailers.[4] Put differently, size-based input price discrimination arises if there are what Katz (1987) labels transactional economies of scale in acquiring an alternative source, such that a large retailer's threat to leave (completely or partly) is stronger than that of smaller retailers.[5]

To prove this formally, Katz (1987) considers a game where the supplier at stage one sets input prices. At stage two, each retailer either accepts the input price he is offered or invests in an alternative source of supply. This constitutes an outside option since the retailers have not made any investments at the time when input prices are determined. Because the retailers' ability to cover the investment costs increases in output, large retailers have stronger investment incentives than small retailers. To prevent the retailers from making such investments on stage two, the supplier offers large retailers a selective rebate on stage one. If the retailers compete in the output market, the large retailers will gain a competitive advantage due to their lower input prices.

In this setting, the supplier will lose profit if it does not price discriminate. To see why, assume that the supplier is obliged by law to charge a common uniform price to all retailers. To keep every retailer aboard, the supplier must reduce all input prices – even those paid by the largest buyers. The fact that uniform pricing prevents the supplier from providing selective rebates to large retailers does not remove the large retailers' threats of investing in the outside option. On the contrary, the threats become stronger; the supplier cannot favor large retailers with lower input prices than those offered to their competitors. To compensate for the lost competitive advantage, the supplier must offer the large retailer

[3] Katz (1987) assumes that the supplier can make take-it-or-leave-it offers. Inderst and Montez (2019) and Foros, Kind and Shaffer (2018) verify that the result holds also if input prices are determined through bargaining processes between the supplier and each retailer.

[4] Large retailers may also achieve a rebate compared to smaller ones if the supplier faces increasing marginal costs in the relevant area (Chipty and Snyder, 1999, and subsequent papers). More precisely, in the set-up of Chipty and Snyder (1999), the larger retailer realizes a size advantage given that the gross surplus function created by the transaction between the supplier and the retailer is concave.

[5] As Doudchenko and Yurukoglu (2016) emphasize in their example of multi-channel television, a large firm as Google does not benefit from any size effect, since it has not enough subscribers in that particular market (i.e., scale). Comcast, in contrast, has a large enough audience to threaten with an alternative source of content supply, which it can also activate at a lower cost than Google. In this example, Comcast has a size advantage that is enabled through transactional economies of scale.

a lower input price. The reduced input prices in turn translate into lower consumer prices, but the supplier is clearly harmed.

Katz (1987) obviously captures important aspects of the relationship between retailers and suppliers. However, there is reason to question the robustness of the prediction that a supplier necessarily prefers to price discriminate. As an example, we observe that digital platforms like Apple and Google commit to a non-discriminatory 30/70 split of revenues with content providers.[6] Another example is the use of most-favored customer clauses between suppliers and retailers to ensure that small and large buyers pay identical input prices. Our main research question is therefore: Could commitment to uniform pricing be an optimal strategy for a supplier if transactional economies of scale would otherwise generate price discrimination?

The answer is yes. To show this, we set up a simple model where a retailer *prior* to the determination of the dominant supplier's input prices, may choose to invest in an alternative source of supply, which for concreteness we may call a private label. The more the retailer invests, the lower the marginal cost of producing the private label. In the words of O'Brien (2014), the retailer has an inside option (as opposed to an outside option as in Katz, where investments are made *after* the price decision) which it may use to press down the input price charged by the supplier. Now, suppose that there are several retailers and that the consumers perceive them as close substitutes. The retailers then compete fiercely, and it is important for each to gain a competitive advantage over its rivals. This business-stealing motivation results in high investments in the inside option, which is bad for the supplier, who is forced to set low input prices. So, what would happen if the supplier could commit to charging the same input price to all retailers (i.e. uniform pricing)? First, we observe that, all else equal, the supplier is worse off by such a commitment, since it would ex-post prefer to charge the small retailer a higher price, i.e. to price discriminate. So, how could the supplier possibly be better off with a commitment to uniform pricing? To answer this, note that when facing uniform prices, no retailer can any longer obtain a competitive advantage by putting pressure on the supplier's input price. The commitment thus affects the retailers' investment incentives (ex ante), which are reduced. That allows the supplier to raise the price, and a commitment to uniform prices could therefore be profitable for the

[6]Apple uses this split independent of whether the decision on retail pricing is delegated (the agency model used for e-books and apps) or whether Apple decides the retail price (the wholesale model used for music in iTunes). See e.g. Gilbert (2015) and Foros, Kind and Shaffer (2017).

supplier. The more substitutable the retailers are for the consumers, the higher is the price increase, and the more profitable is the commitment decision. Since higher input prices translate into higher retail prices, the consumers will be harmed.

It is not always profitable for the supplier to commit to uniform pricing. This is most clearly seen if we assume that the retailers do not compete at all; there is then no business-stealing motivation of investing in the inside option, and the investment level of the largest retailer will then be independent of whether the supplier price discriminates. If the supplier uses uniform pricing in such a case, the only effect will be that it must charge lower input prices from smaller retailers, which clearly would harm the supplier, but be advantageous for the consumers. This result holds also if the competitive pressure between the retailers is relatively weak. Consequently, the supplier and the consumers have conflicting interests both with weak and strong retail competition.

In the spirit of d'Aspremont and Jacquemin (1988), and subsequent papers on strategic R&D investments, we allow for investment spillovers between the retailers. We show that if the supplier price discriminates, and the investment spillover is not too strong, each retailer will strategically over-invest in the inside option to gain a competitive advantage. Under uniform pricing, on the other hand, higher investments by the large retailer will always benefit the small retailers, and the retailers will therefore under-invest in inside options in order to constrain output and increase prices. Strategic over- or under-investments could be used to deter competitors from the industry. This papers contributes with insight on this topic. More precisely, we apply our finding to consider how a large retailer may strategically invest to induce exit (or prevent entry) of smaller rivals.

The concern that input price discrimination causes exit and prevents entry goes back to the Robinson-Patman Act of 1936. We find that if the supplier commits to uniform pricing, the large retailer may induce exit or prevent entry by under-investing in the inside option.[7] The opposite is true under price discrimination unless investment spillovers are sufficiently strong.

[7]Doudchenko and Yurukoglu (2016) empirically quantify how bargaining power related to size affects the analysis of mergers and the profitability of entrants in the US multi-channel TV market. As mentioned above, they estimate that Comcast manages to negotiate about 25 percent lower unit input prices for content than smaller rivals.

3.2 Literature review

As explained above, in contrast to our model, the source of size-based price discrimination in the seminal paper by Katz (1987) is that outside options are available after the input prices are determined. Under uniform pricing, the supplier cannot provide a selective rebate to the large retailer, but the large retailer's bargaining power from the threat of using the outside option does not disappear. Consequently, the supplier offers a lower input price to all retailers to ensure that the large retailer stays on board.[8] Consumer prices are reduced. Since no investments take place, total welfare unambiguously increases if the supplier uses uniform pricing. However, since the supplier is worse off under uniform pricing, the supplier does not want to commit to uniform pricing under binding outside options.

O'Brien (2014) and Akgün and Chioveanu (2019) assume that price discrimination arises due to asymmetries in inside options among the retailers. O'Brien shows that average input prices are typically higher if the supplier cannot use price discrimination. In this case, consumer surplus tends to be higher under price discrimination (in contrast to Katz, 1987). Akgün and Chioveanu (2019) have a model with the same basic mechanisms as ours, but they do not consider differences in size between retailers. More specifically, they assume that the retailers can invest in reducing the cost of accessing a substitute that is offered by a competitive fringe. Their focus is on how a ban on price discrimination affects retailers' innovation incentives, and whether such a ban tends to favor more efficient or more inefficient retailers.

All other things equal, a retailer with lower marginal costs at the retail level has a larger market share than a less efficient rival. However, such asymmetries in retail efficiency cannot explain size-based price discrimination in favor of the large retailer. Quite the opposite; DeGraba (1990) and Katz (1987) show that an unconstrained supplier will price discriminate in favor of the less efficient retailer.[9] If the retailers can invest prior to

[8] In the basic model, Katz (1987) assumes that only the large retailer can invest in the outside option, but in the appendix, he shows that the results hold also when the small retailers can invest in outside options. Katz considers the case where the retailers need to undertake a fixed cost investment to get access to the outside option. The qualitative results are not affected if the retailers instead make investments that reduce the marginal costs. The latter case reflects our model, except for the difference in timing as investments take place after the decision on input prices. See Appendix A.4.

[9] Dukes, Gal-Or and Srinivasan (2006) show the opposite in a bargaining framework. If a large retailer has lower retail marginal costs, there is a potential gain from transferring sales to the more efficient retailer, thus increasing channel profit. Under bargaining, the supplier captures some of the gain from enhanced efficiency. Using the insight that more complex contracts facilitate price discrimination, Inderst and Shaffer

the decision on input prices to reduce retail marginal costs, DeGraba (1990) shows that retailers invest less under price discrimination than under uniform pricing. The reason is that the more a retailer invests in retail marginal cost reductions, the greater the level of price discrimination in disfavor of the more efficient, and consequently larger, retailer. In our setup, we deliberately assume that retailers are equally efficient at the retail level. Consequently, differences in retail marginal costs are not a source of price discrimination in our model.

Inderst and Valletti (2009) combine elements from DeGraba (1990) and Katz (1987). Like DeGraba, they allow retailers to invest in retail marginal cost reductions prior to the supplier's choice of input prices. Like in Katz, retailers may invest in an outside option after input prices are determined, and the threat of using the outside option is more credible for a large than for a small retailer. In contrast to DeGraba (1990), Inderst and Valletti (2009) show that retailers may invest more in retail marginal cost reductions under price discrimination than under uniform pricing.

Like all the above-mentioned papers, we consider linear input pricing. While real-world contracts typically involve more than a simple unit input price, linear input pricing seems to be a more reasonable assumption than non-linear contracts in many markets. One example is grocery retailing. Even though the contracts between suppliers and retailers are complex, comprehensive investigations by competition authorities in the UK and Norway (Competition Commission, 2008; Norwegian Competition Authority, 2019) reveal that rebates are given at the margin and that (average) variable input price components are decreasing in size (see also discussion by Inderst and Valletti, 2009). Linear input price contracts are also widely used in cable-TV markets (Crawford and Yurukoglu, 2012; Crawford et al., 2018; Doudchenko and Yurukoglu, 2016) and in the book publishing industry (see e.g. Gilbert, 2015). Further examples are provided by Gaudin (2019). Iyer and Villas-Boas (2003) provide a theoretical rationale for using linear input pricing.[10]

(2009) show that the more efficient firm obtains the lowest price when the supplier offer two-part tariff contracts. This result arises from the ability of non-linear contracts to extract downstream surplus and incentivize allocative efficiency.

[10]Under non-linear pricing it is crucial whether wholesale contracts are secret or not. Under secret contracts, O'Brien and Shaffer (1992; 1994) show that there will be no price discrimination at the margin from an unconstrained supplier. Instead, input prices at the margin equal the supplier's marginal cost. In contrast to the outcome under non-linear pricing, Gaudin (2019) shows that consumer prices may be higher under secret than observable (and credible) linear input prices. Most of the papers on input price discrimination under non-linear contracts assume an unconstrained supplier. One exception is Inderst and

3.3 The model

We consider a context with $n \geq 2$ intrinsically identical and independent local markets. In each market there is a 'small' retailer, S, which only operates locally ($n_S = 1$). In $n_L \leq n$ of the markets there also exists a 'large' retailer, L. The large retailer has one outlet in each of the markets where it is present. We assume that $n_L \geq 2$.

A dominant upstream supplier U offers each retailer a good that it can resell to the consumers. If retailer i buys the good, it is charged a unit input price w_i ($i = L, S$) by the supplier. Retailers are equally efficient with respect to retail costs. For simplicity, we normalize retailing costs to zero. Hence, asymmetries in retailing costs are not a source of input price discrimination in our model. Operating profit per retail outlet is then equal to $(p_i - w_i)q_i$, where p_i is the consumer price and q_i is output.

Rather than buy from the supplier, retailer i can produce a substitutable good in-house if it has previously made an adequate investment: in the words of O'Brien (2014), the retailer has an inside option. Let o_i denote the marginal cost of producing this inside option. The more the retailer has invested in the manufacturing process, the lower its marginal production cost o_i.[11] In the spirit of the seminal paper by d'Aspremont and Jacquemin (1988) on strategic R&D investments, we open up for the possibility that a retailer which invests in the production of an inside option, may generate positive side effects for the other retailer in the same market (e.g., due to knowledge spillovers concerning production technologies or – in a richer model – greater acceptance of e.g. private labels).

Hence, we assume that the marginal cost of producing the inside option is

$$o_i = 1 - (x_i + \theta x_j), \text{ where } i, j = L, S; i \neq j. \tag{3.1}$$

The parameter $\theta \in [0, 1]$ in equation (3.1) reflects investment spillovers. There are no spillovers if $\theta = 0$, and perfect spillovers if $\theta = 1$.[12]

Shaffer (2019). They show that if retailers have access to outside options, the supplier may reduce the unit input price, and increase the fixed slotting fee, towards one of the retailers, and thereby reduce the value of the outside options for all other retailers.

[11]In grocery markets, among others, one interpretation may be investments in the ability to offer private labels. We could also envisage that each retailer makes investments that increase the consumers' willingness to pay for the private label (e.g., through marketing and quality improvements). The model becomes rather complex if we consider both cost-reducing and value-enhancing investments. To make our points as transparent as possible, we abstract from the latter and assume that the consumers perceive the inside option to be equally good as the original good offered by the dominant supplier.

[12]In (3.1) we have implicitly that the spillovers to the large retailer are independent of how many

The cost of investing x_i is $C(x_i)$, where C is strictly increasing and strictly convex. Since the inside option and the original good are perfect substitutes, retailer i will sell the one which has the lower marginal cost. Defining $z_i = \min\{w_i, o_i\}$, we can write net profit of a representative small retailer and the large retailer, respectively, as

$$\pi_S = (p_S - z_S)q_S - C(x_S) \text{ and} \tag{3.2}$$

$$\Pi_L = \sum^{n_L}(p_L - z_L)q_L - C(x_L). \tag{3.3}$$

In each local market, consumer preferences are defined by a Shubik-Levitan (1980) utility function:[13]

$$\Psi(q_L, q_S) = 2(q_L + q_S) - (1-s)(q_L^2 + q_S^2) - \frac{s}{2}(q_L + q_S)^2, \tag{3.4}$$

where $s \in [0,1]$ reflects the degree of differentiation between the outlets. Specifically, the consumers perceive the large and the small retailers in a given market as perfect substitutes if $s = 1$ and as unrelated if $s = 0$. By allowing imperfect substitutes, $s \in (0,1)$, we analyze a greater variety of market competition than most existing literature.

Consumer surplus in a representative market is given by

$$CS = \Psi(q_L, q_S) - p_L q_L - p_S q_S. \tag{3.5}$$

Solving $\partial CS/\partial q_i = 0$, we find the inverse demand functions

$$p_i = 2 - (1-s)2q_i - s(q_L + q_S). \tag{3.6}$$

Below, we consider a game with the following timing in each of the n identical markets:

- Stage 1: The retailers decide how much to invest in the inside option (L and S choose x_L and x_S, respectively). This determines o_L and o_S.

local markets it operates in. This seems technically reasonable, since the local retailers are identical and consequently make identical technological choices. An alternative specification of the spillover function would be to set $o_L = 1 - (x_L + \theta n_L x_S)$. This would presumably enhance the advantage of operating in several locations (greater economies of scale), but not change the qualitative results.

[13]The demand system by Shubik and Levitan (1980) has an attractive property, since we may vary the degree of substitution among retailers without affecting the size of the market (see e.g. discussion by Inderst and Shaffer, 2019).

- Stage 2: The supplier sets the input prices w_L and w_S that maximize own profit, taking into account the fact that retailer $i = L, S$ will buy the good only if $w_i \leq o_i$.

- Stage 3: L and S decide q_L and q_S, where their marginal costs are given by $z_L = \min\{w_L, o_L\}$ and $z_S = \min\{w_S, o_S\}$, respectively.

The game is solved by backward induction.

3.3.1 Stage 3: Output

At stage 3, the retailers choose their profit-maximizing output. Solving $\partial\pi_i/\partial q_i = 0$, the first-order condition for retailer i is given by

$$\frac{\partial \pi_i}{\partial q_i} = \frac{\partial p_i}{\partial q_i} q_i + (p_i - z_i) = 0. \tag{3.7}$$

This implies that

$$q_i = \frac{2\,(4-3s) - 2\,(2-s)\,z_i + s z_j}{(4-s)\,(4-3s)}. \tag{3.8}$$

3.3.2 Stage 2: The supplier chooses input prices

At stage 2, the supplier offers retailer i the upstream good at price w_i. We normalize all costs for the upstream firm to zero, so that its profit level is given by:

$$u = w_L q_L + w_S q_S. \tag{3.9}$$

If none of the retailers has an adequate inside option, the supplier solves $\max\limits_{w_L, w_S} u$. This yields

$$w_L = w_S = \widehat{w} = 1.$$

Our interest is in the case where retailer i has invested in an adequate inside option, such that $o_i < \widehat{w}$. This means that retailer i's cost of using the inside option is a binding constraint for the upstream firm; the retailer will not buy from the supplier unless $w_i \leq o_i < \widehat{w}$.

3.3.3 Stage 1: Investments by the retailers

Let us now turn to stage 1, where the retailers decide how much to invest in the inside option. Solving $\partial\pi_i/\partial x_i = 0$ for a representative small retailer, and using the envelope theorem, we find

$$\frac{\partial\pi_S}{\partial x_S} = \underbrace{\left[-q_S\frac{dz_S}{dx_S} - C'(x_S)\right]}_{\text{Direct effect}} + \underbrace{\left[\left(\frac{\partial p_S}{\partial q_L}\frac{dq_L}{dx_S}\right)q_S\right]}_{\text{Strategic effect}} = 0. \tag{3.10}$$

The first square bracket of equation (3.10) measures the direct effect of investing in the inside option. The term $(-q_S dz_S/dx_S)$ captures the fact that by increasing x_S by one unit, the production cost for the inside good falls by dz_S/dx_S units for each of the q_S units the retailer sells. Other things equal, it is optimal to invest in the inside option until this marginal benefit is equal to marginal investment costs, $C'(x_S)$. The second square bracket measures the strategic effect of investing in the inside option: since an increase in x_S reduces marginal production costs for the small retailer, the large retailer will respond by changing its output (dq_L/dx_S). This, in turn, affects the price that the small retailer can charge $(\partial p_S/\partial q_L < 0)$. Following Fudenberg and Tirole (1984) and Tirole (1988), we say that the small retailer will strategically over-invest if the second square bracket is positive (which is true if $dq_L/dx_S < 0$), while it will strategically under-invest if the bracket is negative (which is true if $dq_L/dx_S > 0$). We will analyze this in detail below.

For the large retailer, we likewise have

$$\frac{\partial\Pi_L}{\partial x_L} = \underbrace{\left[\sum^{n_L}\left(-q_L\frac{dz_L}{dx_L}\right) - C'(x_L)\right]}_{\text{Direct effect}} + \underbrace{\left[\sum^{n_L}\left(\frac{\partial p_L}{\partial q_S}\frac{dq_S}{dx_L}\right)q_L\right]}_{\text{Strategic effect}} = 0. \tag{3.11}$$

All else equal, investing in more efficient production technology is more profitable for the large retailer; it benefits from lower marginal costs in all the locations in which it operates. Both the direct and the strategic effect of investing are therefore greater for the large retailer than for each of the small retailers, other things equal.

All markets are identical, and it is convenient to define the large retailer's profit in each market where it operates as $\pi_L = \Pi_L/n_L$. This allows us to write the first-order condition for both the small and the large retailer as

$$\frac{\partial \pi_i}{\partial x_i} = \underbrace{\left[-\frac{dz_i}{dx_i} q_i - \frac{C'(x_i)}{n_i} \right]}_{\text{Direct effect}} + \underbrace{\left(\frac{\partial p_i}{\partial q_j} \frac{dq_j}{dx_i} \right)}_{\text{Strategic effect}} q_i = 0, \qquad (i = L, S), \tag{3.12}$$

where $n_i = 1$ for $i = S$ and $n_i = n_L$ for $i = L$. Below, we will discuss when this first-order condition constitutes an optimum.

Input price discrimination (PD)

Let us start out by asking whether the supplier has incentives to price discriminate, i.e. to charge different prices from the large and the small retailers. To answer this question, we can use equation (3.12) to see how the investment incentives for the large and the small retailers depend on the number of outlets of the large retailer:

$$\frac{\partial}{\partial n_L} \left(\frac{\partial \pi_L}{\partial x_L} \right) = \frac{C'(x_L)}{n_L^2} > 0 \text{ and } \frac{\partial}{\partial n_L} \left(\frac{\partial \pi_S}{\partial x_S} \right) = 0. \tag{3.13}$$

Equation (3.13) shows that the larger is the large retailer, the more it invests in the inside good. The size of the large retailer does not directly affect the investment incentives of the small retailers, but it could, nonetheless, have an indirect effect. However, stability requires that $|dx_i/dx_j| < 1$. Since lower costs of producing the inside good force the upstream firm to charge a lower price for the original good, we can conclude:

Lemma 1 *Suppose that the supplier can price discriminate:*

(i) The supplier charges a higher input price to the small retailers than from the large retailer ($z_S > z_L$), and

(ii) more so the larger the size difference between the retailers ($d(z_S - dz_L)/dn_L > 0$).

The mechanism behind the result in the first part of Lemma 1 corresponds to Akgün and Chioveanu (2019). They show that a retailer with lower marginal cost of using the inside option, faces a lower input price. O'Brien (2014) shows in a bargaining framework that a retailer with better inside options than its rival, obtains a lower input price, but O'Brien does not model how asymmetries in inside options may arise. We show that this effect follows from exogenous differences in size between the retailers. Therefore, the ability to invest in inside options may explain size-based input price discrimination in favor of the large retailer, and that the degree of price discrimination is increasing in the size difference between the retailers.

While market players and policy makers often claim that input price discrimination is size-based, the literature only provides economies of scale with respect to outside options (Katz, 1987) and increasing marginal costs at the supplier level (Chipty and Snyder, 1999) as potential explanations for size-based price discrimination. Long-run investment in inside options may be an alternative explanation, and seems to be consistent with the observations that retailers in many industries undertake significant cost-reducing and value-enhancing investments regarding the ability to provide private labels and backward integrate (for further discussion, see the Concluding Remarks).

Let us now investigate how the investment incentives depend on the investment spillovers. We first note that higher investment by firm i affects output of good j as follows:

$$\frac{dq_j}{dx_i} = \underbrace{\frac{\partial q_j}{\partial z_i}\frac{dz_i}{dx_i}}_{<0} + \underbrace{\frac{\partial q_j}{\partial z_j}\frac{dz_j}{dx_i}}_{>0 \text{ if } \theta>0}. \tag{3.14}$$

The more firm i invests in the inside option, the lower its marginal costs ($dz_i/dx_i = -1$). Other things equal, an increase in x_i thus makes the local rival less competitive and induces it to produce less. This is captured by the first term in equation (3.14), which is consequently negative. However, if there are positive investment spillovers, a higher investment by firm i reduces marginal costs also for firm j ($dz_j/dx_i = -\theta$). In isolation, this tends to increase output from firm j, making the second term in equation (3.14) positive if $\theta > 0$. Using equation (3.8), we find that the net effect is

$$\frac{dq_j}{dx_i} = \left[\frac{2\,(2-s)}{(4-s)\,(4-3s)}\right]\left(\theta - \theta^{PD}\right), \quad \text{where } \theta^{PD} \equiv \frac{s}{4-2s}. \tag{3.15}$$

If the spillovers are sufficiently strong, $\theta > \theta^{PD}$, we consequently see that firm j's output is increasing in the investment level of firm i. Using equation (3.6), which implies that $\partial p_i/\partial q_j = -s$ (the negative price effect of greater output from the rival is larger the better substitutes the retailers sell), it follows that the sign of the strategic effect depends on the size of the spillovers:

$$\frac{\partial p_i}{\partial q_j}\frac{dq_j}{dx_i}q_i = -s\left[\frac{2\,(2-s)}{(4-s)\,(4-3s)}\right]\left(\theta - \theta^{PD}\right)q_i < 0 \text{ if } \theta > \theta^{PD}. \tag{3.16}$$

Let us next investigate how one retailer's investment incentives depend on the investment level of the rival. Differentiating equation (3.12) with respect to x_j, we have

$$\frac{\partial^2 \pi_i}{\partial x_i \partial x_j} = \left[\frac{4\,(2-s)^2\,(4-2s-s\theta)}{(4-3s)^2\,(4-s)^2} \right] \left(\theta - \theta^{PD}\right) > 0 \text{ if } \theta > \theta^{PD}, \tag{3.17}$$

which shows that investments are strategic complements if $\theta > \theta^{PD}$ and strategic substitutes if $\theta < \theta^{PD}$.

We can now state:

Proposition 1 *Suppose that the supplier price discriminates, and that*

(i) $\theta < \theta^{PD}$. Each retailer will strategically over-invest in the inside option. Investments are strategic substitutes.

(ii) $\theta > \theta^{PD}$. Each retailer will strategically under-invest in the inside option. Investments are strategic complements.

Figure 3.1 shows how the sign of the strategic effect depends on spillovers and the substitutability between the large and the small retailer in each market. Each retailer wants the rival to produce less. In the figure, this implies that each retailer will over-invest below the upward-sloping line ($dq_j/dx_i|_{\theta<\theta^{PD}} < 0$) and under-invest above it ($dq_j/dx_i|_{\theta>\theta^{PD}} > 0$).

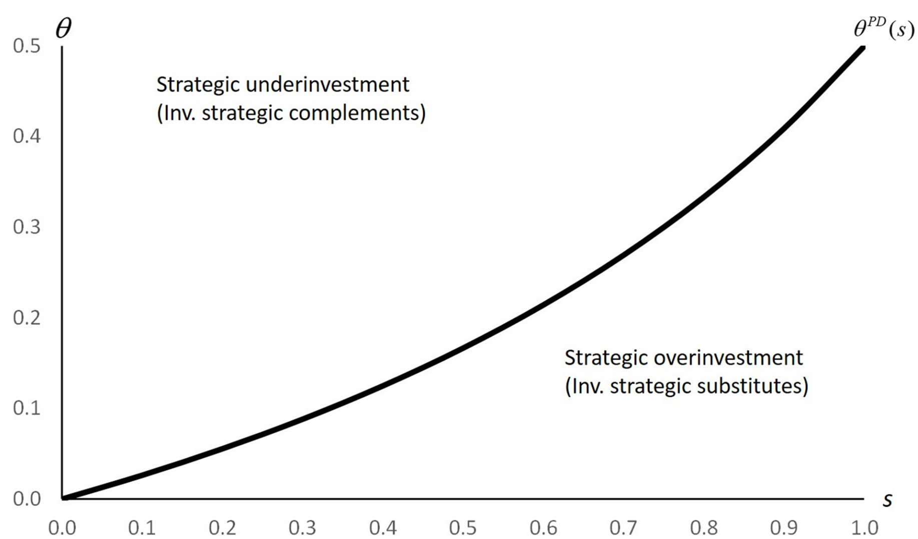

Figure 3.1: Strategic investment behavior.

Equation (3.13) tells us that an increase in n_L has a positive effect on x_L, but only an indirect effect on x_S. The sign of the indirect effect depends on the size of the spillovers, which determines whether investments are strategic substitutes or strategic complements. More precisely, from Proposition 1, we can deduce:

Corollary 1 *The small retailers' investment in inside options is*

a) decreasing in the size of the large retailer ($dx_S/dn_L < 0$) if $\theta < \theta^{PD}$.

b) increasing in the size of the large retailer ($dx_S/dn_L > 0$) if $\theta > \theta^{PD}$.

Uniform pricing (UP)

Now, assume that the upstream supplier does not price discriminate between the large and the small retailers, but rather sets a common $w_L = w_S = w$. At this stage, we will not discuss why it sets a uniform price; it could be due to competition policy. However, we shall also see that the supplier may be better off if it does not price discriminate.

It follows from the analysis above that the large retailer has stronger incentives than the small one to invest in the inside option (this is true independent of whether the supplier price discriminates). The supplier will therefore be able to sell to both types of retailers only if it sets $w \leq o_L$. In an equilibrium where the supplier serves the whole market, we therefore have

$$w = 1 - (x_L + \theta x_S). \tag{3.18}$$

Inserting for this into (3.8), output at stage three can be written as

$$q_L = q_S = \frac{2 - w}{4 - s}. \tag{3.19}$$

The marginal direct benefit for the large firm of investing in the inside option is the same as when the supplier price discriminates; it reduces the per-unit input price from the supplier by one unit ($dw_i/dx_L = -1$). The disadvantage for the large retailer is that the lower input price now also applies for each of the local rivals, which respond by increasing output ($dq_S/dx_L = 1/(4 - s)$). The large retailer will therefore strategically under-invest. More precisely, inserting that $\partial p_L/\partial q_S = -s$ into equation (3.12), we have:

$$\frac{\partial \pi_L}{\partial x_L} = \underbrace{\left[q_L - \frac{C'(x_L)}{n_L}\right]}_{\text{Direct effect}} + \underbrace{\left(-\frac{s}{4 - s}\right) q_L}_{\text{Strategic effect } (<0)} = 0.$$

From equation (3.12), we can write the first-order condition for the small retailers' investment as

$$\frac{\partial \pi_S}{\partial x_S} = \underbrace{\left[\theta q_S - C'(x_S)\right]}_{\text{Direct effect}} + \underbrace{\left(-\frac{\theta s}{4-s}\right) q_S}_{\text{Strategic effect } (<0)} = 0.$$

Since $\partial \pi_S / \partial x_S|_{x_S=0} = \theta q_S \frac{2(2-s)}{4-s} - C' > 0$ if $C'(0)$ is not too steep, it is optimal for the small retailers to invest if $\theta > 0$ (for simplicity, we have assumed that there are no fixed costs involved in investing in the inside option). The small retailers have no incentives to invest in the inside option if $\theta = 0$. The marginal effect on the input price of investing is $dw/dx_S = -\theta$.

We further have

$$\frac{\partial^2 \pi_S}{\partial x_S \partial x_L} = \frac{2\,(2-s)}{(4-s)^2}\theta \text{ and } \frac{\partial^2 \pi_L}{\partial x_S \partial x_L} = \frac{4-2s}{(4-s)^2}\theta.$$

In contrast to what we found under price discrimination, investments are now always strategic complements.

We can conclude:

Proposition 2 *Assume uniform pricing and that $\theta > 0$. All retailers will strategically under-invest in inside options. Investments are strategic complements.*

3.4 Comparison of input price discrimination and uniform pricing

3.4.1 Inducing exit (or preventing entry)

So far, we have looked at the question of whether the retailers have incentives to over-invest or under-invest in the inside option, given that the rival(s) will remain in the market. In the public debate, much attention has been given to the question of whether price discrimination in favor of large retailers prevents entry or, analogously, induces exit of smaller rivals. In our framework, will the large retailer have incentives to strategically over-invest in the inside option in order to reduce the profitability of the small retailers? This could induce exit if the retailers e.g. have fixed operating costs that they need to cover. To answer this question, we must examine how the large retailer's investment level affects profit for a small rival (i.e. not only the large retailer's own profit, which we looked at above). Using the envelope theorem, we have

$$\frac{d\pi_S}{dx_L} = q_S \left[\frac{\partial p_S}{\partial q_L} \frac{dq_L}{dx_L} + \left(-\frac{dw_S}{dx_L} \right) \right] = q_S \left[-s \frac{2\left(2-s\right) - \theta s}{\left(4-s\right)\left(4-3s\right)} + \theta \right]. \tag{3.20}$$

The more the large retailer invests in the inside option, the more it will sell (because the supplier will be forced to charge a lower input price). This will harm the small retailers if $s > 0$, and explains why the first term in the square bracket of equation (3.20) is negative. The second term, however, is positive if there are positive spillovers, such that the small retailers' marginal costs are decreasing in the large retailer's investment level. Whether the first or the second term dominates, depends on the size of the spillovers. More specifically, we find:

$$\frac{d\pi_S}{dx_L} = \frac{4\left(2-s\right)^2}{\left(4-s\right)\left(4-3s\right)} \left(\theta - \theta^{PD}\right) q_S.$$

If $\theta < \theta^{PD}$, we thus have $\frac{d\pi_S}{dx_L} < 0$. In this case, the large retailer can induce exit or prevent entry by over-investing in the inside option.

If the supplier does not price discriminate, higher investments by the large retailer will always benefit the small retailers:

$$\frac{d\pi_S^{UP}}{dx_L} > 0.$$

If the large retailer wants to induce exit under uniform pricing, it will therefore under-invest in inside options.

We can state:

Proposition 3 *Under uniform pricing, the large retailer may induce exit (prevent entry) by under-investing in the inside option. The opposite is true under price discrimination, unless spillovers are sufficiently strong ($\theta > \theta^{PD}$).*

3.4.2 Who benefits from uniform pricing (and who benefits from price discrimination)?

Henceforth, we abstract from entry and exit decisions, and we ask who is better off under price discrimination and who is better off under uniform pricing? We show that the degree of competition among retailers has critical impact on the answer to this question.

If there are perfect spillovers ($\theta = 1$), the costs of using the inside option will be the same for all the retailers. Then, their investment levels do not depend on whether the supplier in principle is able to price discriminate; the uniform pricing and price discrimination regimes are identical. In the rest of this paper, we will focus on the opposite extreme, and set $\theta = 0$. We will then analyze how the differences between the price discrimination and the uniform pricing regimes depend on the competitive pressure among the retailers, as measured by the substitutability parameter s. In order to obtain closed-form solutions, we further assume the simple quadratic investment cost function, $C(x_i) = (\gamma/2)x_i^2$. Our interest is in stable equilibria where both the large and the small retailers are operative and, in Appendix A.1, we show that all the necessary conditions for the existence of such equilibria are satisfied if $\gamma \geq 8$ and $n_L < 6$. We therefore set $C(x_i) = 4x_i^2$ and let $n_L \in [2, 6)$.

Consumers perceive the retailers as perfect substitutes ($s = 1$)

As a starting point, assume that the consumers perceive the large and the small retailers to be perfect substitutes ($s = 1$). The large retailer invests more in the inside option than any of its competitors, and will therefore be charged a lower input price by the supplier if the supplier can price discriminate. More precisely, we have

$$w_L^{PD} = \frac{16\,(6 - n_L)}{96 - 11n_L},\; w_S^{PD} = \frac{10\,(9 - n_L)}{96 - 11n_L};\; w_S^{PD} - w_L^{PD} > 0. \tag{3.21}$$

All calculations in this section are shown in Appendix A.2. The more outlets the large retailer has, the more it will invest in the inside option and the less will it be charged by the supplier ($dw_L^{PD}/dn_L < 0$). This means that the competitiveness of the small retailers is decreasing in n_L, so that their marginal profitability of investing in the inside option is also decreasing in n_L. This, in turn, allows the supplier to charge them an input price which is increasing in n_L ($dw_S^{PD}/dn_L > 0$).

The profit level at each outlet equals

$$\pi_L^{PD} = \frac{100\,(9 - n_L)}{(96 - 11n_L)^2},\ \pi_S^{PD} = \frac{32\,(6 - n_L)^2}{(96 - 11n_L)^2} => \pi_S^{PD} - \pi_L^{PD} < 0. \tag{3.22}$$

Since the input price for the large retailer is decreasing in its number of outlets, its profit level is increasing in n_L ($d\pi_L^{PD}/dn_L > 0$), while the opposite is true for the small retailers ($d\pi_S^{PD}/dn_L < 0$). Not surprisingly, profit per outlet is greater for the large than for the small retailers. We further find that consumer surplus and the profit level for the supplier are equal to, respectively,

$$CS^{PD} = \frac{18\,(11 - n_L)^2}{(96 - 11n_L)^2} \text{ and } u^{PD} = \frac{60\,(6 - n_L)\,(17 - n_L)}{(96 - 11n_L)^2}. \tag{3.23}$$

Equation (3.23) implies that $dCS^{PD}/dn_L > 0$ and $du^{PD}/dn_L < 0$. This simply reflects the fact that the direct effect of the large retailer increasing its size is that the supplier is forced to charge a lower input price to the large retailer, which partly spills over to lower consumer prices from the large retailer. This effect dominates over the indirect effect that the small retailers can be charged a somewhat higher input price if n_L increases (so that consumer prices from the small retailers increase).

If the supplier does not discriminate, we have

$$w^{UP} = 2\frac{18 - n_L}{36 - n_L}. \tag{3.24}$$

As expected, we find $dw^{UP}/dn_L < 0$; the large retailer invests more in the inside option the more locations it operates in, and thereby forcing the supplier to charge a lower price.

In Appendix A.2, we show that joint profit for the n_L outlets of the large retailer is greater than the profit level of a representative local competitor ($n_L\pi_L^{UP} - \pi_S^{UP} > 0$). However, an interesting difference from the price discrimination case is that since the small retailers can now free-ride on the investments undertaken by the large retailer, the large retailer makes a smaller profit at each location than its rival:

$$\pi_L^{UP} = \frac{144 - 4n_L}{(36 - n_L)^2},\ \pi_S^{UP} = \frac{144}{(36 - n_L)^2};\ \pi_S^{UP} - \pi_L^{UP} = \frac{4n_L}{(36 - n_L)^2} > 0. \tag{3.25}$$

It is straight forward to show that $w_L^{PD} < w^{UP} < w_S^{PD}$; the uniform input price lies between the low input price that the large retailer would otherwise pay and the high input price faced by the local retailers. This corresponds to the findings by Akgün and Chioveanu (2019).[14] The large retailer will consequently have to pay a higher input price under uniform pricing, and its competitive advantage over the small retailers erodes. For the same reason, a uniform price is unambiguously good for the small retailers; they will become more competitive, and also pay a lower input price.

Consumer surplus and profit for the supplier under uniform pricing equal

$$CS^{UP} = \frac{288}{(36 - n_L)^2} \text{ and } u^{UP} = \frac{48\,(18 - n_L)}{(36 - n_L)^2}. \tag{3.26}$$

In parallel to the results above, we have $dCS^{UP}/dn_L > 0$ and $du^{UP}/dn_L < 0$. More interestingly, from equations (3.23) and (3.26), we find that $u^{UP} > u^{PD}$. The supplier is thus better off if it charges the same price to each of the retailers than if it price discriminates. The difference is, moreover, increasing in n_L. The intuition for why it is advantageous for the supplier not to price discriminate, is that the large retailer will then have less incentives to invest in the inside option, since it cannot obtain any competitive advantage. The supplier can therefore charge a higher input price to the large retailer under uniform pricing than under price discrimination ($w^{UP} > w_L^{PD}$). The higher input price is partly passed on to the consumers, and from equations (3.23) and (3.26), it follows that $CS^{UP} < CS^{PD}$.

Other things equal, it is a dominant strategy for the supplier to price discriminate at stage two of the game if the retailers differ in their investments in inside options. Unless the supplier can credibly commit to uniform pricing before the retailers invest, we will therefore have a unique equilibrium where the supplier price discriminates.

Proposition 4 *Assume that the consumers perceive the large retailer and the small retailers as perfect substitutes. The supplier will then commit to uniform pricing if it is able to do so, and this will harm the consumers.*

As discussed in the Introduction, competition policy might require dominant suppliers to not price discriminate. This could solve the commitment problem for the supplier. Indeed, even if competition authorities do not actively pursue the non-discrimination policy,

[14] As emphasized above, they do not consider differences in size among the retailers, but assume that one of the retailers may be more efficient with respect to investments in inside alternatives.

one might imagine that the supplier could appeal to the competition law to signal that it cannot price discriminate. An alternative device for committing to uniform pricing, is through a price-parity clause with at least one of the retailers in each market. When retailers' products are perfect substitutes, both the supplier and the small retailers in each market prefer uniform pricing. Consequently, they all benefit from such a clause.

It is interesting to compare the results above with those of Katz (1987), who assumes $s = 1$. A retailer can credibly threaten to *ex post* invest in an outside option (e.g. backward integration) unless the supplier charges a sufficiently low input price. As in our model, a large retailer has greater incentives than smaller retailers to invest in an alternative source of supply due to economies of scale. Katz derives conditions under which none of the firms will actually invest in the outside option. He finds that under reasonable assumptions, uniform pricing (e.g. due to a ban on price discrimination) can lower the input prices that the supplier charges from both the large and the small retailers. Consumer prices will then unambiguously fall, in contrast to what we find.

Before we leave the comparison with Katz (1987) for now, we note that welfare under price discrimination and welfare under uniform pricing in our case are given by, respectively,

$$W^{PD} = \frac{10\left(1035 - 226n_L + 11n_L^2\right)}{\left(96 - 11n_L\right)^2} \text{ and } W^{UP} = \frac{4\left(360 - 13n_L\right)}{\left(36 - n_L\right)^2}. \tag{3.27}$$

It can be shown that $W^{UP} > W^{PD}$ in the relevant area ($2 \leq n_L < 6$); total welfare is higher under uniform pricing than under price discrimination. The difference is, moreover, increasing in n_L, as shown in Figure 3.2. Consequently, a ban on price discrimination is arguably beneficial both in Katz's and our context, albeit for very different reasons. In Katz (1987) a ban is welfare improving because a *threat* of investing in an outside option forces the supplier to charge lower input prices. However, no investments actually take place in the equilibrium Katz analyzes. In contrast, in our model at least the large firm will make investments, but this will be in inside options that are not used *per se*; it invests to press down the price of the good it actually sells in equilibrium. In this sense, investments constitute a negative welfare effect.

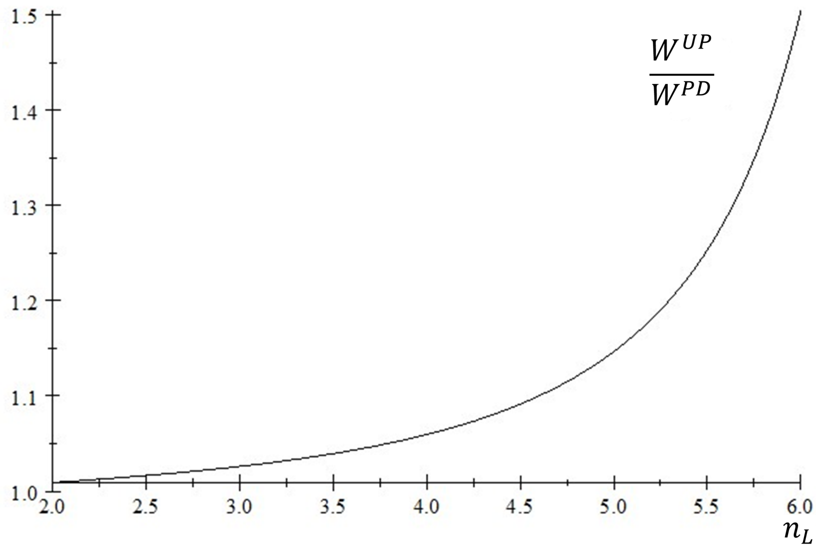

Figure 3.2: Welfare higher under uniform pricing than under price discrimination ($s = 1$)

Consumers perceive the retailers as unrelated ($s = 0$)

With $s = 0$, there is no competition between the retailers. Clearly, also in this case each of the local retailers invests less than the large retailer. They will therefore be charged a higher input price and be less profitable than the large retailer (all calculations in this section are shown in Appendix A.3):

$$w_L^{PD} = 2\frac{16 - n_L}{32 - n_L}, w_S^{PD} = \frac{30}{31}; w_S^{PD} - w_L^{PD} > 0 \text{ and } \pi_S^{PD} - \pi_L^{PD} < 0. \tag{3.28}$$

Turning to the regime with uniform pricing, note that since there is no retail competition, the large retailer's investment level is independent of which prices the small retailers charge. The supplier will consequently not be able to sell to the large retailer if it charges more than w_L^{PD}. Clearly, it does not want to charge a lower price either, so in equilibrium, we have

$$w^{UP} = w_L^{PD} = 2\frac{16 - n_L}{32 - n_L} < w_S^{PD}. \tag{3.29}$$

With $s = 0$, price discrimination thus harms the small retailers, but has no effect on the large retailer.

The fact that the small retailers can free-ride on investments by the large retailer, implies that we also now find that the profit level per outlet is highest for the former,

$\pi_S^{UP} > \pi_L^{UP}$. It is nonetheless still true that $n_L \pi_L^{UP} - \pi_S^{UP} > 0$.

Since the small retailers pay lower input prices with uniform pricing than with price discrimination, while the input price for the large retailer is independent of the price regime, it immediately follows that uniform pricing harms the supplier and benefits consumers who buy from the small retailers. More precisely, we have

$$u^{UP} - u^{PD} = -\frac{16\,(16+15n_L)}{961\,(n_L-32)^2}\,(n_L-1) < 0, CS^{UP} - CS^{PD} = \frac{64\,(63-n_L)}{961\,(32-n_L)^2}\,(n_L-1) > 0.$$

We can now state:

Proposition 5 *Assume that the consumers perceive the large retailer and the small retailers as unrelated (independent in demand). The supplier will price discriminate if it is able to do so, and this will harm the consumers.*

Finally, note that the loss in market power for the supplier implies that the dead-weight loss falls. Since the small retailers moreover save investments, welfare is necessarily highest under uniform pricing. As for $s = 1$, the welfare gain of uniform pricing is increasing in n_L.

Retailers are imperfect substitutes ($0 < s < 1$)

The analysis above indicates that the supplier prefers uniform pricing if the competitive pressure between the stores is sufficiently strong (i.e., for sufficiently high values of s), while the opposite is true for the consumers. This is illustrated graphically in Figure 3.3 (for $n_L = 2$). If it is observed that suppliers commit to uniform pricing (e.g., price-parity clauses) or appeal to the competition law to justify non-discrimination, policy makers should thus be skeptical. If suppliers appear to be negative to uniform pricing, on the other hand, we have an indication that uniform pricing would benefit the consumers. However, signals from suppliers should be interpreted with caution, since they can clearly have incentives to mislead policy makers.[15]

[15] According to our analyses, the arguments for allowing price discrimination is stronger if policy makers care about consumer surplus rather than about total welfare (i.e., if they abstract from the resource costs of higher investments in inside options). Katz (1987) focuses on the case where retailers credibly threaten to invest in an outside option, but where the outside options will not be used in equilibrium since the supplier responds by reducing input prices. In his framework (where it is assumed that the stores are perceived as perfect substitutes), a ban on price discrimination is therefore welfare improving if it increases consumer surplus.

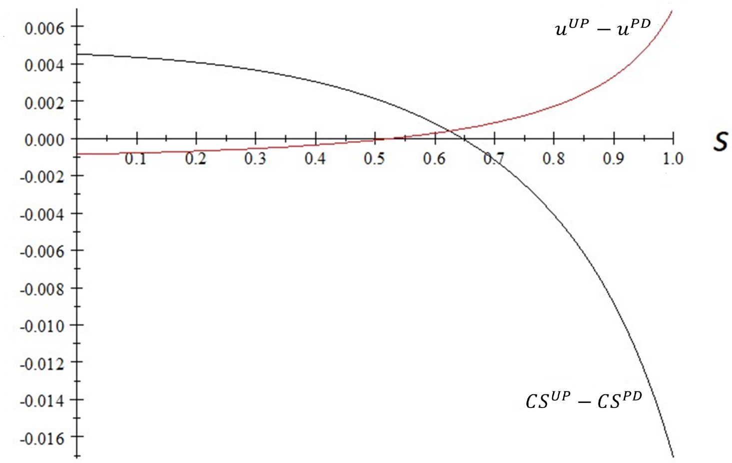

Figure 3.3: Consequences of price parity for the supplier and for the consumers.

3.5 Concluding remarks

We show how investments in inside options may give rise to size-based input price discrimination. The important distinction between outside and inside options is whether the investments take place before or after the supplier's decision on input prices. This distinction may have crucial impact on suppliers' incentives to price discriminate. In practice, retailers may improve their position towards suppliers through investments ex ante the negotiation with suppliers, as well as through a credible threat of switching to an outside option ex post of the negotiations.

Let us further discuss our applications from the Introduction; the grocery market, the book publishing market, and the multi-channel TV market. In grocery retailing, private labels may constitute an alternative source of supply. For many products, retailers probably need to make significant investments prior to negotiations over input prices with the brand suppliers to have a credible threat from private labels. If retailers decide to backward integrate and switch to a private label, they probably need to undertake further investments. With respect to investments in private labels, there may also be significant investment spillovers that retailers need to consider. If one retailer succeeds in introducing a private label in one product category, this will probably make it easier for a rival retailer to do the same.[16]

[16]Market shares of private labels differ between markets, but inside market differences among competing retailers are smaller.

Amazon obtains low input prices from suppliers (publishers) due to its size.[17] Gilbert (2015, page 174) argues that an important part of Amazon's position is that they have a credible threat to backward integrate: "Publishers have the additional concern that they will become an antiquated and redundant component of the book industry as Amazon increasingly deals directly with authors to supply books. Publishers fear that Amazon will 'disintermediate' the supply chain, replacing the traditional role of publishers to source and distribute content." This example illustrates that Amazon's credible threat comes from a combination of inside and outside options. Amazon undertakes investments into backward integration (Amazon Publishing) which proves their ability to switch to an alternative source of supply.

In the multi-channel TV market, a large player like Comcast, with its 23 million subscribers, has a size advantage over smaller rivals, such as Google Fiber and Cablevision, when it comes to using an alternative source of supply through backward integration into content programming. Doudchenko and Yurukoglu (2016) refer to the fact that Google Fiber emphasizes that they face a significant disadvantage due to size-based input price discrimination in favor of larger rivals such as Comcast. This certainly indicates that transactional economies of scale are needed to have a credible size advantage. In general, Google is one of the largest firms in the world. By the same token, the buyer group of smaller cable TV firms (the National Cable Television Cooperative) fails to achieve size-based rebates, since they cannot coordinate backward integration on behalf of their members (Doudchenko and Yurukoglu, 2016). Also in this example it seems reasonable that cable-TV providers need to make investments prior to the negotiations over content input prices in order to credibly threaten to – overnight – go to an alternative source of supply. Nonetheless, it will involve further costs if they put their threat into action.

It is obviously a question of to which extent a supplier can commit to uniform pricing. In our model, if the supplier cannot commit to uniform pricing, it will provide a selective rebate to the large retailer. In several markets, we observe that firms that control wholesale terms of trade may commit to non-discriminatory rules. In other markets, we observe that firms are lobbying for non-discriminatory obligations, such as net-neutrality. Indeed, even

[17] Gilbert (2015, page 173) writes "Amazon could seek to exploit its power as a large buyer to obtain low wholesale prices, rebates, or other concessions from its suppliers, and a credible concern is that Amazon will continue to press its suppliers for better terms. Publishers complain that at Amazon, today's wholesale price is the starting point for tomorrow's negotiations."

if competition authorities do not actively pursue the non-discrimination policy, one might imagine that the supplier could appeal to the competition law to signal that it cannot price discriminate.

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Appendix

A.1 Existence of stable equilibria

In this appendix, we show the necessary conditions for the existence of stable equilibria where both the large and the small retailers are operative. It suffices to show this for $s = 1$, since the requirement will be stricter than with any lower value of s.

Insering (3.8) into (3.2) and (3.3), we have profit for retailer i, $\pi_i = \frac{(1-x_j-2x_i)^2}{9} - \frac{C(x_i)}{n_i}$, where $C(x_i) = (\gamma/2)x_i^2$. The stable equilibrium must satisfy the following two conditions:

1. The second-order condition: $d^2\pi_i/dx_i^2 < 0$, and
2. Stability: $|dx_i/dx_j| < 1$.

For $i = L$, we have that the second-order condition $d^2\pi_L/dx_L^2 = -(9\gamma - 8n_L)/9n_L < 0$ holds if $\gamma \geq \frac{8n_L}{9}$, and that the stability condition $|dx_L/dx_S| = -4n_L/(9\gamma - 8n_L) < 1$ is satisfied for $\gamma \geq 4n_L/3$. The latter is the stricter requirement that ensures the existence of stable equilibria.

Restricting our attention to the cases where $n_L < 6$, we must have that $\gamma \geq 8$ to ensure stable equilibria.

A.2 Consumers perceive the retailers as perfect substitutes ($s = 1$)

In this appendix, we demonstrate all calculations that are presented in section 3.4.2, where consumers perceive the firms as perfect substitutes, $s = 1$. The model, including the timing of the game, is presented in section 3.3. The game is solved by backwards induction.

Stage-three output is solved in equation (3.8). At the second stage, the supplier sets the input prices that maximize their own profits given that the retailer will only buy the good if $w_i \leq o_i$. In equilibrium, this will be binding, such that $z_i = o_i$. Therefore, we insert equation (3.1) into equation (3.8), to find the stage-two output

$$q_i = \frac{1 - x_j + 2x_i}{3}. \tag{A.1}$$

Stage 1: Optimal investments Moving to the first stage of the model, we distinguish between the two potential pricing regimes: input price discrimination and uniform pricing.

Input price discrimination At the first stage, retailer i solves $\partial\pi_i/\partial x_i = 0$, and we derive the best-response functions:

$$x_L(x_S) = \frac{n_L - n_L x_S}{18 - 2n_L};\ x_S(x_L) = \frac{1 - x_L}{16}.$$

Solving these simultaneously, yields the following optimal investments:

$$x_L^{PD} = \frac{5n_L}{96 - 11n_L} \tag{A.2}$$

and

$$x_S^{PD} = \frac{6 - n_L}{96 - 11n_L}. \tag{A.3}$$

From the optimal investment levels in (A.2) and (A.3), we then obtain the values of the input prices (as given in section 3.4.2):

$$w_L^{PD} = 1 - x_L^{PD} = 16\frac{6 - n_L}{96 - 11n_L};\ w_S^{PD} = 1 - x_S^{PD} = 10\frac{9 - n_L}{96 - 11n_L}. \tag{A.4}$$

This implies that $w_S^{PD} - w_L^{PD} = \frac{6}{96-11n_L}(n_L - 1) > 0$, which means that there is input price discrimination in favor of the large retailer, such that the small retailer pays a higher input price.

From equation (A.4), we find that $dw_L^{PD}/dn_L = -\frac{480}{(11n_L-96)^2} < 0$ and $dw_S^{PD}/dn_L = \frac{30}{(11n_L-96)^2} < 0$.

Once we have found the optimal investments in (A.2) and (A.3), and the input prices in (A.4), the subsequent expressions in section 3.4.2 follow directly.

Inserting (A.2) into (3.3), we obtain the profit of the large and the small retailer, respectively, given by the expressions in (3.22).

Combining (A.2) and (A.3) with (3.5) and (3.9), we find consumer surplus and the supplier's profit, respectively, as given in equation (3.23).

From equation (3.22), we find that the large retailer obtains a higher profit than the small retailer

$$\pi_S^{PD} - \pi_L^{PD} = -\frac{4\,(63 - 8n_L)}{(96 - 11n_L)^2}(n_L - 1) < 0. \tag{A.5}$$

Using equation (3.22), we find that $d\pi_L^{PD}/dn_L = 100\frac{11n_L-102}{(11n_L-96)^3} > 0$ and $d\pi_S^{PD}/dn_L =$

$-1920\frac{n_L-6}{(11n_L-96)^3} < 0$.

From equation (3.23), we find that $dCS^{PD}/dn_L = 900\frac{n_L-11}{(11n_L-96)^3} > 0$ and $du^{PD}/dn_L = 60\frac{61n_L-36}{(11n_L-96)^3} < 0$.

Total welfare is the sum of retail profits, supplier profit and consumer surplus:

$$W^{PD} = CS^{PD} + u^{PD} + \pi_L^{PD} + \pi_S^{PD} = \frac{10\left(1035 - 226n_L + 11n_L^2\right)}{\left(96 - 11n_L\right)^2}. \tag{A.6}$$

Uniform pricing Suppose next that the supplier does not price discriminate, and offers both retailers the same, uniform, input price w.

When there is no price discrimination, the supplier must give all retailers the same take-it-or-leave-it offer. The supplier will be able to sell to both types of retailers only if it sets $w \leq o_L$ (i.e., the large retailer's integration constraint binds for both retailers). In equilibrium, we find that the input price is

$$w = 1 - x_L. \tag{A.7}$$

At the first stage, each retailer i solves $\partial\pi_i/\partial x_i = 0$, and we find the optimal investments:

$$x_L^{UP} = \frac{n_L}{36 - n_L} \text{ and } x_S^{UP} = 0. \tag{A.8}$$

It then follows directly from (A.7) that $w^{UP} = 1 - x_L^{UP} = 2\frac{18-n_L}{36-n_L}$ (equivalent to equation 3.21). Comparing this with (A.4), we see directly that $w_L^{PD} < w^{UP} < w_S^{PD}$.

We find that $dw^{UP}/dn_L = -\frac{36}{(n_L-36)^2} < 0$; the large retailer invests more in the inside option the more locations it operates in, and this forces the supplier to charge a lower price.

By inserting (A.8) into equations (3.2) and (3.3), we obtain the retailers' profits under uniform pricing as given by equation (3.25).

Equation (3.25) states that the small retailer receives a higher profit than the large retailer under uniform pricing. However, the joint profit for all $n_L < 6$ outlets is greater than the small retailer's profits: $n_L\pi_L^{UP} - \pi_S^{UP} = -\frac{4n_L}{(n_L-36)}(n_L^2 - 36n_L + 36) > 0$.

Combining (A.8) and equations (3.5) and (3.9), gives us the consumer surplus under uniform pricing and the supplier's profit, in equation (3.26).

From equation (3.26), we find that $dCS^{UP}/dn_L = -\frac{576}{(n_L-36)^3} > 0$ and $du^{UP}/dn_L = 48\frac{n_L}{(n_L-36)^3} < 0$.

Comparing (3.23) and (3.26), we find that

$$CS^{UP} - CS^{PD} = \frac{288}{(36-n_L)^2} - \frac{18\,(11-n_L)^2}{(96-11n_L)^2} < 0$$

and

$$u^{UP} - u^{PD} = -\frac{1}{(n_L-36)^2}\,(48n_L - 864) - 60\,(n_L-6)\,\frac{n_L-17}{(11n_L-96)^2} > 0.$$

Thus, the consumers prefer price discrimination, whereas the supplier prefers uniform pricing when consumers perceive the retailers as perfect substitutes.

Finally, total welfare is

$$W^{UP} = CS^{UP} + u^{UP} + \pi_L^{UP} + \pi_S^{UP} = \frac{4\,(360-13n_L)}{(36-n_L)^2}. \tag{A.9}$$

Comparing (A.6) and (A.9), we find that

$$W^{UP} - W^{PD} = -\frac{1}{(n_L-36)^2}\frac{(52n_L-1440)}{(110n_L-2260n_L+10350)}(11n_L-96) > 0.$$

Hence, in terms of total welfare, uniform pricing is preferred when consumers perceive the retailers as perfect substitutes.

A.3 Consumers perceive the retailers as unrelated ($s = 0$)

In this appendix, we demonstrate all calculations that are presented in section 3.4.2, where consumers perceive the firms as unrelated, $s = 0$. We proceed as we did in Appendix A.2, and demonstrate all the calculations in section 3.4.2. As above, output at the third stage is given by equation (3.8). We distinguish between the two potential pricing regimes, input price discrimination and uniform pricing.

Input price discrimination ($s = 0$) We regard the case where $z_i = o_i$ binds at the second stage. Inserting equation (3.1) into equation (3.8), assuming $\theta = 0$ and $s = 0$, we have stage-two output given by

$$q_i = \frac{1+x_i}{4}. \tag{A.10}$$

At the first stage, retailer i solves $\partial\pi_i/\partial x_i = 0$, and we derive the optimal investments:

$$x_L^{PD} = \frac{n_L}{32 - n_L};\, x_S^{PD} = \frac{1}{31}. \tag{A.11}$$

By inserting (A.11) into equation (3.1), we find the optimal input prices given by equation (3.28). The local (small) retailer is charged more than the large retailer:

$$w_S^{PD} - w_L^{PD} = \frac{32}{31\,(32 - n_L)}\,(n_L - 1) > 0. \tag{A.12}$$

Combining (A.11) with (3.2) and (3.3), we obtain retail profits: $\pi_L^{PD} = \frac{4}{32-n_L}$ and $\pi_S^{PD} = \frac{4}{31}$. This implies that $\pi_S^{PD} - \pi_L^{PD} = -\frac{4}{31(32-n_L)}\,(n_L - 1) > 0$.

Combining (A.11) with (3.5) and (3.9), we obtain the consumer surplus and the profit for the supplier, respectively:

$$CS^{PD} = \frac{64\,(1985 - 64n_L + n_L^2)}{961\,(32 - n_L)^2} \text{ and } u^{PD} = \frac{16\,(30\,736 - 1921n_L + 15n_L^2)}{961\,(32 - n_L)^2}. \tag{A.13}$$

Total welfare is the sum of retail profits, supplier profit and the consumer surplus:

$$W^{PD} = \frac{4}{961\,(n_L - 32)^2}\left(107n_L^2 - 11\,653n_L + 217\,200\right). \tag{A.14}$$

Uniform pricing ($s = 0$) Suppose next that the supplier does not price discriminate, and offers both retailers the same, uniform, input price w.

At stage three, the retailers choose quantities. Solving $\partial\pi_i/\partial q_i = 0$, we find optimal quantities at stage three (equation 3.8, with $s = 0$, $\theta = 0$, and $z_i = z_j = w$).

$$q_i = \frac{2 - w}{4}.$$

At the second stage, the input price will be determined by the large retailer's investments, such that

$$w = o_L = 1 - x_L. \tag{A.15}$$

At the first stage, retailer i solves $\partial\pi_i/\partial x_i = 0$, and we derive the optimal investments:

$$x_L^{UP} = \frac{n_L}{32 - n_L};\, x_S^{UP} = 0. \tag{A.16}$$

By inserting (A.16) into (A.15), we find the uniform input price $w^{UP} = 2\frac{16-n_L}{32-n_L}$.

Retail profits become

$$\pi_L^{UP} = \frac{128 - 4n_L}{(n_L - 32)^2};\ \pi_S^{UP} = \frac{128}{(n_L - 32)^2}.$$

This implies that the small retailer obtains a higher profit than the large retailer, $\pi_S^{UP} - \pi_L^{UP} = \frac{4n_L}{(n_L-32)^2} > 0$. However, the joint operating profit of the large retailer exceeds the operating profit of the small competitor, $n_L\pi_L^{UP} - \pi_S^{UP} = -\frac{4}{(n_L-32)^2)}(n_L^2 - 32n_L + 32) > 0$.

Combining (A.16) with (3.5) and (3.9), we find consumer surplus and profit for the supplier, respectively:

$$CS^{UP} = \frac{128}{(32 - n_L)^2} \text{ and } u^{UP} = \frac{32\,(16 - n_L)}{(32 - n_L)^2}. \tag{A.17}$$

Comparing (A.17) and (A.13), we find that

$$u^{UP} - u^{PD} = -\frac{16\,(16 + 15n_L)}{961\,(n_L - 32)^2}\,(n_L - 1) < 0$$

and

$$CS^{UP} - CS^{PD} = \frac{64\,(63 - n_L)}{961\,(32 - n_L)^2}\,(n_L - 1) > 0.$$

By comparing the results of price discrimination and uniform pricing, we now see that the consumers prefer uniform pricing, whereas the supplier prefers price discrimination. Both of these results are opposite from when consumers perceive the retailers as perfect substitutes ($s = 1$).

Total welfare under uniform pricing is the sum of retail profits, supplier profit and consumer surplus:

$$W^{UP} = CS^{UP} + u^{UP} + \pi_L^{UP} + \pi_S^{UP} = \frac{4}{(n_L - 32)^2}\,(224 - 9n_L)\,. \tag{A.18}$$

Comparing (A.14) and (A.18), we find that uniform pricing is always preferred, in terms of total welfare, $W^{UP} - W^{PD} = -\frac{4}{961(n_L-32)^2}\,(107n_L^2 - 3004n_L + 1936) > 0$.

A.4 Investment in marginal-cost reduction in outside options

In this appendix, we show (as promised in footnote 8) that the qualitative results of Katz (1987) are not affected if the retailers make investments that reduce the marginal costs rather than the fixed costs, to get access to the alternative source of supply. This reflects our model, but where we switch the timing; investments are made after the decision on input prices. The timing of the game is as follows (note that the order of stages one and two is switched from our model):

- Stage 1: The supplier sets input prices w_L and w_S that maximize own profit, taking into account that retailer $i = L, S$ will buy the good only if the retailer's profit from buying from the supplier (no integration) exceeds the profit from backwards integration ($\pi_i^{NI} \geq \pi_i^I$).

- Stage 2: The retailers decide how much to invest in the inside option (L and S choose x_L and x_S, respectively). This determines o_L and o_S. The retailers accept the supplier's offer, or reject it and invest in marginal-cost reductions in the outside option.

- Stage 3: The retailers compete à la Cournot; L and S decide q_L and q_S, where their marginal costs are given by $z_L = \min\{w_L, o_L\}$ and $z_S = \min\{w_S, o_S\}$, respectively.

The game is solved by backwards induction.

Stage 3: Cournot ($s = 1$) The basic set-up for the model, including the third stage of the game, is given in the main text. For the purpose of this appendix, we assume $\theta = 0$ and $s = 1$.

Stage-three outputs are solved in equation (3.8):

$$q_i = \frac{2 - z_j - 2z_i}{3} \tag{A.19}$$

where $z_i = \min\{w_i, o_i\}$.

Discriminatory pricing

Stage 2: Investments At the second stage, the retailers face two sourcing alternatives.

First, the retailers can buy the product directly from the supplier (and make no investments, i.e. no integration). Then, we set $z_i = w_i$ and $x_i = 0$ for all i. The non-integration profit (superscript 'NI') becomes

$$\pi_i^{NI} = \frac{(2 + w_j - 2w_i)^2}{9}. \tag{A.20}$$

The second alternative is to acquire the product from an alternative source (integrate backwards), such that $z_i = o_i = 1 - x_i$. Then, the integration profit (superscript 'I') becomes

$$\pi_i^{I} = \frac{(2 + (1 - x_j) - 2\,(1 - x_i))^2}{9} - \frac{C(x_i)}{n_i}. \tag{A.21}$$

The retailer i maximizes profits with respect to the investment level, $\partial\pi_i/\partial x_i = 0$. The best-response functions are

$$x_L(x_S) = \frac{n_L - n_L x_S}{18 - 2n_L};\; x_S(x_L) = \frac{1 - x_L}{16}.$$

Solving these simultaneously, yields the following optimal investments:

$$x_L^{PD} = \frac{5n_L}{96 - 11n_L};\; x_S^{PD} = \frac{6 - n_L}{96 - 11n_L}.$$

Inserting the optimal investments into equation (A.21) yields the integration profit for platform i, for $i = L, S$,

$$\pi_L^{I} = 100\frac{9 - n_L}{(11n_L - 96)^2};\; \pi_S^{I} = 32\frac{(n_L - 6)^2}{(11n_L - 96)^2}. \tag{A.22}$$

Stage 1: Supplier chooses input prices At the first stage, the supplier chooses input prices. The supplier maximizes profits, such that the retailers are indifferent between buying from the supplier, and acquiring the product elsewhere. It follows that (A.20) must equal (A.22), and we solve for w_i and find the best-response functions (in Katz's words: the integration frontier):

$$w_i(w_j) = 1 + \frac{w_j}{2} - \frac{\sqrt{9}}{2}\sqrt{\pi_i^I}.$$

From the best-response functions, we find that the integration frontier is upward sloping ($\partial w_L(w_S)/\partial w_S = 1/2 > 0$), similar to Katz (1987).

We solve the two best-response functions simultaneously, and find optimal input prices

$$w_i^{PD} = 2 - 2\sqrt{\pi_i^I} - \sqrt{\pi_j^I}. \tag{A.23}$$

Observe that $w_L^{PD} < w_S^{PD}$ (since $\pi_L^I > \pi_S^I$), and we have input price discrimination in favor of the large retailer. In equilibrium, the retailers will not make any investments, such that $x_i = 0$ for all $i = L, S$. Inserting (A.23) into (A.20), retailer profits from buying from the supplier (no integration) are $\pi_L^{PD} = 100\frac{9-n_L}{(11n_L-96)^2}$ and $\pi_S^{PD} = 32\frac{(n_L-6)^2}{(11n_L-96)^2}$.

Uniform pricing ($z_i = w$)

Stage 2: Optimal investments Suppose now that the supplier only offers one uniform price to the retailers, such that $z_i = w$. Again, the retailer has two sourcing alternatives. It can buy from the supplier, for which $z_i = w$ and $x_i = 0$ for all i. Then, non-integration profit for retailer i is:

$$\pi_i^{NI} = \frac{(2-w)^2}{9}. \tag{A.24}$$

Alternatively, it can integrate backwards into supply and use an outside option, in which case $z_i = o_i = 1 - x_L$. This means that the input price is determined by the large retailer's investments. Then, integration profit for retailer i is given by

$$\pi_i^I = \frac{(2-(1-x_L))^2}{9} - \frac{C(x_i)}{n_i}. \tag{A.25}$$

Taking the derivative of equation (A.25) with respect to investments x_i, $\partial \pi_i/\partial x_i = 0$, yields the optimal investment levels $x_L^{UP} = \frac{n_L}{36-n_L}$ and $x_S^{UP} = 0$. We observe that $x_L^{UP} < x_L^{PD}$, so the incentives of the large retailer change with the pricing regime. The retailers' integration profits are

$$\pi_L^I = \frac{4}{36 - n_L}; \; \pi_S^I = \frac{144}{(n_L - 36)^2}. \tag{A.26}$$

Stage 1: Supplier chooses input prices At the first stage, the supplier chooses input prices, such that the retailers are indifferent between buying from the supplier, and acquiring the product elsewhere. It follows that (A.24) must equal (A.26), and solve for a common w^{UP}:

$$w^{UP} = 2 - 6\sqrt{\frac{1}{(36 - n_L)}}. \tag{A.27}$$

Comparing (A.27) with (A.23), we observe that $w^{UP} < \frac{w_L^{PD} + w_S^{PD}}{2}$. Thus, the supplier offers a uniform input price to all retailers that is lower than the average prices charged under price discrimination. This corresponds to Katz's Lemmas 1 and A.1. Hence, the qualitative results of Katz (1987) are the same whether we consider fixed-cost investments or marginal-cost reducing investments.