Norwegian School of Economics
Bergen, Fall 2020

The Importance of Multi-Homing: Merger Implications in the Digital Newspaper Market

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Master thesis, Economics and Business Administration

Major: Economic Analysis

NORWEGIAN SCHOOL OF ECONOMICS

Acknowledgements

We would like to thank our supervisor Professor Hans Jarle Kind for contributing with his exceptional insight within industrial organisation. It was his lectures that sparked our growing interest for this field of economics. His availability and constructive feedback has been highly motivating and invaluable throughout the writing process.

Norwegian School of Economics

Bergen, December 2020

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Abstract

In this paper we analyse the choice of consumer prices and qualities and welfare implications from a merger in the digital newspaper market. In this market, the digital newspapers sell access to consumers and the attention of these consumers to advertisers. This media market has been extensively researched, mostly due to this two-sided nature, but most papers assume that the consumers buy one and only one variant of a good. However, a large share of the Norwegian population read two or more digital newspapers on an average day, a behavior referred to as multi-homing. We contribute to the existing literature by relaxing the assumption and allow for multi-homing. To assess the merger implications, we present two version of a theoretical model and compare across the two versions. Our main contribution is that we find greatly differing implications of a merger when consumers multi-home compared to when they buy access to only one digital newspaper. We find that a merger leads to increased average consumer price and quality provided when consumers buy access to only one digital newspaper. Moreover, even though consumers are strictly worse off, a merger can actually be welfare enhancing. Howbeit, when allowing for multi-homing consumers, we find that the competing digital newspapers are strategically independent on the consumer side of the market, while the merged digital newspapers will charge higher prices to the advertisers for the consumers they share. The competition flips to the other side of the market, leaving the consumers unaffected by a merger and letting the advertisers bear the burden. Still, as the digital newspapers extract the lost surplus of the advertisers, the total welfare is in fact left unaffected by a merger under multi-homing.

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1 Introduction

Newspapers have had an impact on society for centuries, and keeping up with the news is part of most people's daily routine. This media market has experienced large digital disruptions the last few decades. The arrival of the internet in the early 90's sparked the rapid technological development which has led to the accessibility of products like smartphones, laptops and tablets in almost every household. In 2019, 90 percent of the population in Norway used the internet on a daily basis on some form of technological device (Medienorge, n.d.-b). This technological development has compelled the newspaper publishers to find new innovative ways to distribute daily news to the public. One such approach is the introduction of the digital newspaper.

Digital newspapers was introduced in the Norwegian market as early as the mid 90's, but has had a prominent growth over the last ten years (Høst, 2020). From offering printed newspapers at a local shop, the public could now consume the news when and wherever they wanted. An interesting characteristic of the business model for both types of newspapers is their dependence on advertisement revenue, which leads to competition on two sides of the market. They must not only compete for consumers to use their services, they also sell the attention of these consumers to the advertisers. The strategic decisions of the newspapers on one side of the market can then be affected by the other side. This characteristic of this media market has made it a popular topic for research within industrial organisation.

However, this business model has made the newspapers particularly vulnerable to changes in the advertiser market (Høst, 2020). From 2015 to 2019 the newspaper publishers lost 30 percent of their advertisement revenue due to the entry of global dominant media firms like Google and Facebook in the Norwegian media market (Medietilsynet, 2020). Google and Facebook possess large quantities of high quality data regarding the Norwegian population, enabling them to deliver highly personalised advertisement. This has made them more attractive to the advertisers, which has led several newspapers to experimenting with new ways of capitalising on their digital offerings (Medietilsynet, 2018). The most common way has been to offer a paid online subscription with exclusive articles, a digital version of their printed newspaper and/or unique digital features.

Implementing some sort of paid online subscription seems to have become the norm for most digital newspapers. From 2010 to the end of 2019, the amount of digital newspapers with some sort of paid online subscription increased drastically from 1 to 89 percent, as depicted in figure 1.1 (Medienorge, n.d.-a).

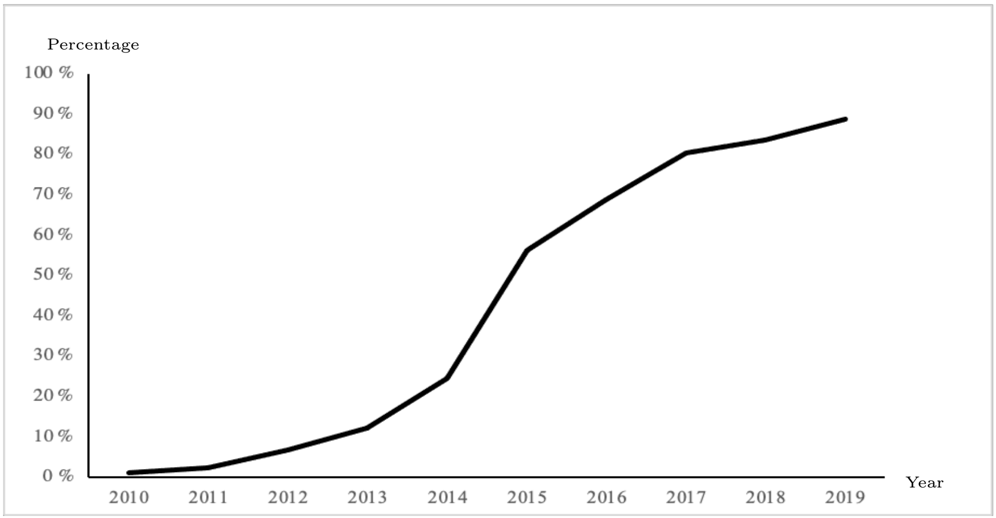

Figure 1.1: *Share of digital newspapers offering a paid online subscription 2010-2019*

The transition to online subscriptions meant that the readers went from consuming all digital news for "free" to having to pay to get access to all of their offerings.[1] As an example, the amount of free articles in many local digital newspapers is limited compared to the amount of paid articles. This has brought about the importance for good quality offerings from the paid digital newspapers. Moreover, the existence of social media and the increase in "fake news" has made it crucial for the digital newspapers to preserve their reputation as a credible information source. This may be achieved through investing in high quality journalism. In summary, this implies that quality is an important decision variable for the digital newspapers in this market.

A fascinating consequence of the two-sided nature of this media market, is that standard economic predictions do not always hold. Firms in such industries can behave in

[1]Note that "free" means no monetary payment, only exposure to advertisement. Hence, if they dislike advertisement it may not be perceived as free.

ways that may not be optimal for firms in traditional one-sided markets. This has been emphasised in regards to analyses of merger implications, where conventional anti-trust rationality do not necessarily apply (Kind & Sørgard, 2013). Indeed, failing to account for the two-sidedness in merger analyses can result in harming the consumers and the welfare as a whole. This has drawn our attention to the possible significance of another interesting characteristic of this media market, namely multi-homing.

In economic theory, it is referred to as multi-homing when a consumer buys several variants of a differentiated product. The alternative is single-homing, where the consumers buy only one variant. In fact, in 2019, as much as 35 percent of the Norwegian population read two or more digital newspapers on an average day, compared to 19 percent that read only one (Medienorge, n.d.-c).[2] We have identified some characteristics for this media market that might be the reason why so many consumers choose to read more than one digital newspaper. Firstly, due to technology like smartphones, the consumers can effortlessly access multiple digital newspapers at once compared to when the newspapers are printed. Secondly, several digital newspapers have distinct offerings in terms of content and digital features. This leads us to believe that some of the consumers value having access to several paid online newspaper subscriptions. Despite the media market being extensively researched, surprisingly few papers account for the possibility of multi-homing consumers.

In light of this, we question how the decisions for price and quality of the digital newspapers might be affected by the existence of multi-homing consumers in the market. Moreover, what will be the welfare implications of a merger in such a market under multi-homing compared to single-homing?

To our surprise there is no existing literature that analyses the merger implications in this type of media market with multi-homing consumers when additionally allowing for quality investments.[3] However, there are a few papers that analyse some of the aspects of interest. Anderson, Foros, and Kind (2019) analyses merger incentives in a media market

[2]The source states similar numbers for the last few years, but does not specify whether only visiting the website of the digital newspaper counts as reading.

[3]This is to the best of our knowledge.

and the possibility for multi-homing, but they do not include quality. They show that multi-homing leads to strategic independence between the competing firms for consumer prices and that a merger flips competition to the other side of the market. Brekke, Sicilian, and Straume (2017), on the other hand, analyses a merger in a market where firms compete in both prices and qualities. Interestingly, they find that, even though consumers are worse off, a merger can be welfare enhancing. However, their analysis is in the context of only single-homing consumers and specifically a one-sided market. Our thesis is aimed to contribute in closing the gap in the existing literature on merger implications in the media market, as well as open up for further research on the topic.

We start out by presenting two versions of our theoretical model. In the first version we restrict attention to consumers who only buy access to one digital newspaper, while in the second version we allow consumers to buy access to two of them. The digital newspapers sell access to the consumers, and charge advertisers for the attention of these consumers, thereby accounting for the two-sided nature of this media market. Although previous literature have shown that an important implication of multi-homing is consumer prices being strategically independent, we are presumably the first to examine quality investments in this setting. Firstly, our model provides us with an unexpected result, as we find strategic independence for qualities in addition to consumer prices under multi-homing.

Secondly, we proceed to examine how a merger can affect the pricing and quality decisions of the competing digital newspapers. Remarkably, the effects differ greatly depending on whether we account for multi-homing consumers in our model. The strategic interaction in the first version yields higher average consumer price and quality provided in the market after merger. Contrarily, the strategic independence in the second version leaves the consumer prices and qualities unaffected. Strikingly, multi-homing flips the competition to the advertisers on the other side of the market.

To assess the merger implications for the consumers and the society as a whole, we compare the welfare changes across the two versions of our model. Our third and main contribution arises from this analysis. We are able to show how the impacts of a merger can greatly differ when we account for multi-homing consumers in this market. Indeed, results suggest that consumers are strictly worse off under single-homing, while they are unaffected under multi-homing. Although our results for the total welfare are likewise striking, they are far more complex. Interestingly, we find that a merger can be welfare enhancing under single-homing: given that consumers (i) are compensated enough by the higher average quality provided, through a sufficiently high marginal valuation of quality, (ii) do not have strong personal preferences for the digital newspapers. In stark contrast, we show that the total welfare under multi-homing is completely unaffected by a merger, stemming from the strategic independence between the digital newspapers. These results shed light on the importance of accounting for multi-homing consumers when assessing the implications of a merger in this type of market. This leads us to believe that our thesis is an important contribution to the existing literature on merger implications as well as multi-homing in general.

The remainder of this thesis proceeds as follows. In section 2, we will give an overview of the most relevant literature and theory. In section 3, we present the two versions of our model and the equilibrium outcomes both before and after a merger. Section 4 includes the welfare analysis of the merger implications of both versions of the model. In section 5 we discuss our findings and propose extensions for further research, before we finally conclude in section 6.

2 Theory and Literature

In this section of the thesis we will present the theories and literature we have based our model on. We start out by describing how product differentiation is often used to explain how firms are able to set prices different from the competitive price. We discuss the results of a rather simple and intuitive model of purely vertical product differentiation. We proceed to present the frameworks for analysis of horizontal product differentiation developed by Hotelling (1929) and Salop (1979). For Hotelling models we discuss previous findings for (and formally examine) the incentives for maximal or minimal differentiation. Furthermore, with the media market in focus, we describe two-sided markets and how they differ from traditional one-sided markets. Then continue on to present theory and highlight implications of both multi-homing and mergers. Lastly, we touch on economic welfare.

2.1 Product Differentiation

When analysing duopoly markets with price competition one usually starts out with a standard Bertrand approach. In this approach, one assumes that the firms produce homogeneous goods which are perfect substitutes in the eyes of the consumer. This assumption implies that the consumer will choose to buy from the producer who charges the lowest price. Hence, by undercutting the price set by the rival, the firm can capture the entire market. *The Bertrand Paradox* states that, even in a market with only two firms, the unique equilibrium has the two firms charge the competitive price and neither firms make profits.[4] As firms will want to avoid this zero-profit state, one possible way of softening the price competition is through product differentiation.

Firms can choose either a vertical or horizontal approach to product differentiation. For vertically differentiated products, all consumers would prefer one of the goods to the other when sold at the same price. A widely used example for this is quality. Specifically, consumers will typically have a higher willingness to pay for a Porsche car than for a

[4] Where the competitive price is equal to the firm's marginal cost, as no firm is willing to price below their marginal cost.

Fiat car. For horizontally differentiated products, on the other hand, the optimal choice of product depends on the particular consumer, as tastes vary among consumers in the population. An example of this is choosing between the same type of soda from different brands. Some consumers may prefer Coca Cola, while other consumers swear to Pepsi Cola. Another example is location, where consumers will prefer to go to a shop that is closest to their location.

Tirole (1988) presents a rather simple and intuitive analysis of vertical differentiation in oligopolistic competition using quality differentiation. Here the willingness to pay of the consumer can be expressed by $U = \theta s - p$, which is the utility of consuming one unit of quality s and paying price p. Here θ represents the taste for quality and it is uniformly distributed across the population. Firm i produce a good of quality s_i $(i = 1, 2)$ where $s_2 \geq s_1$. The unit cost of production is c regardless of type of quality. He considers a two-stage game where firms choose quality in stage one and compete in prices in stage two. Using backwards induction, he shows that in stage two the high-quality firm charges a higher price than the low-quality firm. The high-quality firm also makes a higher profit. In the first stage, the firm with the low quality product will gain from reducing their quality to the minimum, while the firm with the high quality product will gain from increasing their quality. In this model of purely vertically differentiated product, if the firms were to produce the same quality, it leaves each consumer's demand the same because the extra quality merely cancels out when comparing the goods. This demand neutrality will leave the prices unaffected. When solely considering vertical differentiation, the lack of differentiation will intensify price competition and lead to the Bertrand paradox. So even though increasing quality is costless, the low quality firm will want to lower their quality to the minimum to soften price competition.[5]

Spatial analysis can be used to analyse firms' incentives to horizontally differentiate themselves. Hotelling (1929) introduced a model of horizontal product differentiation in a duopoly, which has become a standard model for spatial analysis. Here he introduced a *"linear city"* of length 1, where consumers are uniformly distributed with density 1 along this interval and the two firms A and B compete over these consumers (depicted in

[5] Which implies maximal differentiation.

Figure 2.1). The two firms sell the same physical good and their location is the only way they are differentiated. After simultaneously choosing their location, they observe these locations and then choose their prices simultaneously. In his model he assumes that the market is covered, in that all consumers will either choose to buy only one good from either firm A or B.

The consumers incur a transportation cost t per unit of length and this transportation cost is meant to capture the disutility the consumer faces from consuming a good that does not exactly match their preferences. It can in this particular case be interpreted as the intensity of preference for consuming a product closest to their location.[6] Hence, the goods are more horizontally differentiated for the consumer when this transportation cost is higher: when t increases, both firms compete less vigorously for the same consumers. On the other hand, when t is equal to zero, the consumers go to either store for the same cost and the absence of product differentiation will lead to the Bertrand Paradox.

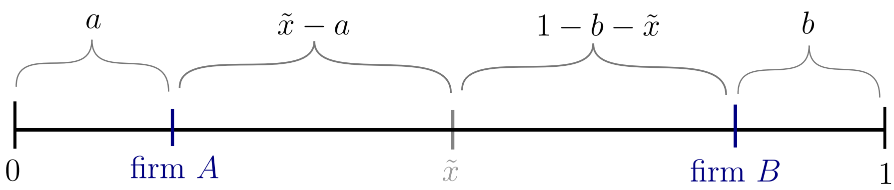

Figure 2.1: *Illustration of Hotelling's Linear City*

The utility from buying the product from firm A for a consumer located at $\tilde{x}$ can be represented in utility form as

$$U_A = v - p_A - t|\tilde{x} - a| \tag{2.1}$$

While the utility of this consumer from buying from firm B would then be

$$U_B = v - p_B - t|(1 - b) - \tilde{x}| \tag{2.2}$$

where v represents the gross surplus each consumer derives from consuming a good. p_A and p_B is the price charged to the consumers for the good of firm A and B, respectively.

[6]At equal prices, the consumer will thus choose to buy from the firm closest to its own position on the line.

Firm A is located at point $a \geq 0$ and firm B at point $1 - b$, where $b \geq 0$ and without loss of generality, $1 - a - b \geq 0$.[7] Thus, the transportation cost of buying from firm A is $t|\tilde{x} - a|$, while the transportation cost of buying from firm B is $t|(1 - b) - \tilde{x}|$.

We find the location of the indifferent consumer by expressing the utilities of buying from each of the firms equal to each other ($U_A = U_B$) and isolating $\tilde{x}$. From the formulation of the model all consumers located to the left of this point ($\tilde{x}$) will buy from firm A, while all consumers located to the right of this point ($1 - \tilde{x}$) will buy from Firm B.

We can then express the demand faced by Firm A and Firm B as

$$D_A(p_A, p_B) = \tilde{x} = \frac{1 - b + a}{2} - \frac{p_A - p_B}{2t}$$

$$D_B(p_A, p_B) = 1 - \tilde{x} = \frac{1 + b - a}{2} - \frac{p_B - p_A}{2t}$$

Consumers located in a and b can then be interpreted as the loyal customers which will buy from firm A and firm B, respectively. We can see that at equal prices, the firms share the consumers located between a and b.

Hotelling (1929) argued that locating in opposite extremes is not a stable equilibrium given linear transportation cost. He found that either firm would increase its marginal profits by moving closer to its competitor. This has later been referred to as *the minimum differentiation principle.* d'Aspremont, Gabszewicz, and Thisse (1979) reexamined the results of Hotelling using quadratic transportation cost and showed that no pure-strategy equilibrium exists if the firms are not located far away enough from each other. They claimed that for any given pair of locations, each firm gains an advantage from moving away as far as possible from the other. This corresponds to maximal differentiation.

We can formally examine what forces implies maximal or minimal product differentiation in this type of framework. Let us assume the profit of firm A is given by

[7] We see that $a = b = 0$ corresponds to maximal differentiation, while $a + b = 1$ corresponds to minimal differentiation in this model.

$\pi_A = (p_A - c)D_A$, where c is the cost of producing one unit of the good. For this type of game we can use backwards induction to solve for optimal prices in the second stage and then solve for optimal choice of location in the first stage.[8] The profit of firm A in the first stage can be written as

$$\pi_A = (p_A^*(a,b) - c)D_A(p_A^*(a,b), p_B^*(a,b))$$

Where p_A^* and p_B^* denotes the equilibrium prices found in the second stage for firm A and firm B, respectively.

Differentiating with respect to location yields

$$\frac{\partial \pi_A}{\partial a} = D_A \frac{\partial p_A^*}{\partial a} + (p_A^* - c)\left(\frac{\partial D_A}{\partial a} + \frac{\partial D_A}{\partial p_A^*}\frac{\mathrm{d}p_A^*}{\mathrm{d}a} + \frac{\partial D_A}{\partial p_B^*}\frac{\mathrm{d}p_B^*}{\mathrm{d}a}\right) = 0$$

We can rearrange this to

$$\frac{\partial \pi_A}{\partial a} = \left[D_A + (p_A^* - c)\frac{\partial D_A}{\partial p_A^*}\right]\frac{\mathrm{d}p_A^*}{\mathrm{d}a} + (p_A^* - c)\left[\frac{\partial D_A}{\partial a} + \frac{\partial D_A}{\partial p_B^*}\frac{\mathrm{d}p_B^*}{\mathrm{d}a}\right] = 0$$

We recognise the term in the first bracket of this equation as the *first order condition*'s of firm A from calculating their optimal price in stage two. From *the envelope theorem* this term will then be equal to zero.

We are then left with

$$\frac{\partial \pi_A}{\partial a} = (p_A^* - c)\left[\overset{+}{\frac{\partial D_A}{\partial a}} + \overbrace{\overset{+}{\frac{\partial D_A}{\partial p_B^*}}\overset{-}{\frac{\mathrm{d}p_B^*}{\mathrm{d}a}}}^{-}\right] = 0$$

We can see directly from the demand function of firm A that the effect of increasing a is positive ($\frac{\partial D_A}{\partial a} > 0$). Moving towards the middle will increase firm A's demand, which can be interpreted as the demand effect of moving toward the competitor. Looking at firm A's demand we see that an increase in competitor's price also will increase their demand ($\frac{\partial D_A}{\partial p_B^*} > 0$). On the other hand, moving towards the

[8] As the firms will anticipate how its choice of location will affect their demand as well as the intensity of price competition.

competitor corresponds to less differentiation, leading to the competitor decreasing its price ($\frac{\partial p_B^*}{\partial a} < 0$) and a decrease in competitor price leads to a decrease in own demand ($\frac{\partial D_A}{\partial p_B}\frac{\partial p_B}{\partial a} < 0$). This can be interpreted as the strategic effect of moving away from your competitor.[9] If the demand effect is larger, each firm will increase their marginal profit by moving toward their competitor to capture more of the demand. While if the strategic effect is larger, each firm will increase their marginal profit by moving further away from their competitor to capture the strategic advantage of their competitor increasing their price, in turn allowing them to increase their own price.

To analyse a market with more than two firms, Salop (1979) introduced a variant of the traditional Hotelling (1929) model, where consumers are located uniformly, with unitary density, on a circle with a perimeter equal to 1 (referred to as *Salop's circular city*). The firms are symmetrically located around the circle with distance $\frac{1}{n}$ between them, where n denotes the number of firms, and all travel occurs along the circle. From the specifications of the model, each firm competes only with their two closest neighbours located at each side of the firm. As this framework allows for three or more firms in the market, it makes it a practical tool for analysing the effects of a merger while avoiding a monopoly market.[10]

In the original model, Salop considered the two-stage game: in the first stage, potential entrants simultaneously choose whether or not to enter. The firms do not choose their location, but rather are automatically located equidistant from one another on the circle.[11] In the second stage, firms compete in prices given the choice of entry.

[9]The demand and strategic effect are also referred to as the direct and indirect effect.

[10]In contrast to Hotelling's linear city, where the framework only enables analysis of competition between two firms.

[11]Notice that maximal differentiation in terms of location is then exogenously imposed.

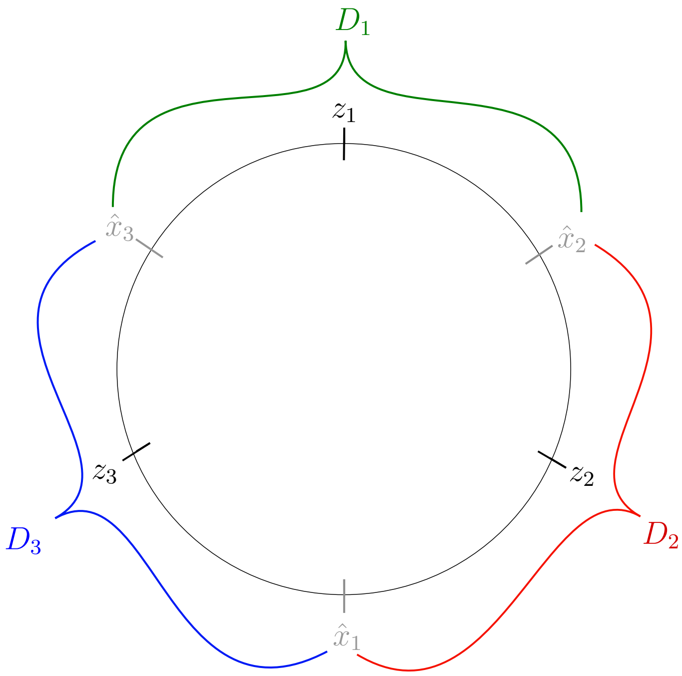

Figure 2.2: *Illustration of Salop's Circular City*

The illustration above is an example of Salop's circular city with $n = 3$ firms. Firm 1 is located at z_1, firm 2 at z_2 and firm 3 at z_3. Given linear transportation cost, the indifferent consumer between buying from firm 1 and 2 is given by $t\hat{x}_2 + p_1 = t(\frac{1}{3} - \hat{x}_2) + p_2$ and the indifferent consumer between buying from firm 1 and firm 3 is given by $t\hat{x}_3 + p_3 = t(\frac{1}{3} - \hat{x}_3) + p_1$.

The demand from the *"right"* side of the market for firm 1 is

$$\hat{x}_2 = \frac{1}{6} - \frac{p_1 - p_2}{2t}$$

while the demand from the *"left"* side of the market for firm 1 is

$$\frac{1}{3} - \hat{x}_3 = \frac{1}{6} - \frac{p_1 - p_3}{2t}$$

The total demand faced by firm 1 is then

$$D_1 = \hat{x}_2 + (\frac{1}{3} - \hat{x}_3) = \frac{1}{3} - \frac{2p_1 - (p_2 + p_3)}{2t}$$

Hence, the demand is directly affected by the price choice of the competitor in each direction, illustrating that there is direct competition for consumers in each direction with a different neighbour. Solving the two stage game using backwards inductions results in a price p_1 dependent on n, meaning the number of firms is endogenous, and it is determined from the zero-profit condition of the incumbent firms. One can use this result to analyse a firm's incentive to enter the market as well as the socially optimal number of firms.

2.2 Two-Sided Markets

The theory on two-sided markets first emerged at the turn of the millennium where Rochet and Tirole (2003) and Caillaud and Jullien (2003) are credited for their pioneering work. In the beginning the theory was developed in relations to credit cards, but it quickly became evident that the theory also applied to many other markets like newspapers, dating clubs and video games. In later years, two-sided markets have been analysed quite extensively and is a very active area of research in economics.

A two-sided market involves two different customer groups who interact through intermediaries, often called platforms. The two-sidedness comes from the interrelation between the demands of the two customer groups. For credit-card companies, consumers experience more value of having a credit-card if more stores accept it, and on the other hand, stores might see a higher value of accepting that type of credit-card if more consumers own it. Here, both sides of the market clearly experience positive externalities as the other side grows. The media market, however, differs in a way that the externalities might not be positive both ways. On one side, the platform (newspaper) will attract more advertisers if they have a lot of consumers (readers), and the advertisers will no doubt get a higher utility as the number of consumers grow. But, on the other side, consumers might not necessarily get a higher utility as the number of ads increase. This will depend on whether consumers like or dislike advertising, which implies there might be negative externalities. The platform has to take both sides into account in their pricing structure, in contrast to the traditional one-sided markets.

Armstrong (2006) argues that there are three main factors that determine the prices offered to the two groups. First, the relative size of the cross-group externality. If members of one group exerts a huge positive externality on the members of the other group, this group will be targeted more aggressively. Second, if they charge fixed fees or per-transaction, this will affect how one side of the market is directly dependent on the other side. Lastly, whether the groups single-home or multi-home.[12]

Consumers' attitude towards advertising has been a subject of research for many years, but there is still no clear answer. Research done by Kaiser and Song (2009) on the printed media market in Germany show that readers in general do not seem to dislike advertising. Some appreciate it when it is relatively informative, but tip towards disliking it when it is uninformative. Similar results were found when Depken and Wilson (2004) analysed how advertising impacted subscription magazines in the US in the late 90s. In which advertising can be perceived as both good and bad. In contrast, looking at the television market Wilbur (2008) found that an increase in the advertising time decreased the audience size on a highly rated broadcast network by a significant amount, and that viewers tend to be averse to advertising.

In later years, there has been an increase in personalised advertising online through social network sites (SNS) and cookies. Tran (2017) finds that consumers are more positive and less likely to avoid ads when they are personalised, because they perceive them as more credible.[13] Welrave, Poels, Antheunis, Van den Broeck, and Noort (2018) provided results of a similar kind when they conducted a within-subjects experiment on adolescents for personalised SNS advertising. They found that the highest level of personalisation generated the most positive response. Various studies on the two-sided media market consider the consumers to dislike advertisement (e.g. Dietl, Land, and Lin (2013); Kind, Nilssen, and Sørgard (2007)), while others consider them to be ad-neurtal (e.g. Kind, Schjelderup, and Stähler (2013); Anderson, Foros, and Kind (2018)).

2.3 Multi-Homing

When a consumer buys only one variant of a horizontally (and vertically) differentiated good we say that they single-home or single-purchase. In contrast, if they buy more

[12]Which we will discuss more in depth later in the following section.
[13]This study is on Facebook in particular.

than one variant, they multi-home or multi-purchase. As an example, there are people who subscribe to both HBO and Netflix, while others are only willing to pay for one streaming service. It is not uncommon for coffee lovers to have both a french press and a single-serve coffee machine. However, some will swear to only use a traditional brewer. A consumer who multi-homes gets an additional utility from the second variant that they would not get from purchasing the same good twice.

In the original formulation of both Hotelling and Salop, consumers are allowed to buy only one good or from one firm, exclusively. This works when we assume that the goods are homogeneous, as there would be no incentives to, in example, buy two of the same newspaper. But as shown earlier, variety matters, and if the goods have different attributes some consumers will buy both variants. Kim and Serfes (2006) was one of the first to relax this assumption in a Hotelling framework. By allowing consumers to make multiple purchases, they show that under certain conditions, Hotelling's result of minimum differentiation is restored.[14]

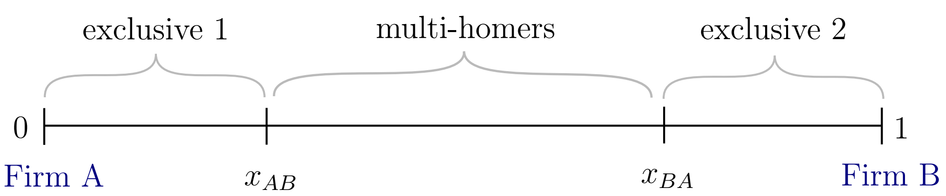

Figure 2.3: *Illustration of Hotelling's Linear City with multi-homing consumers*

Figure 2.3 illustrates a hotelling framework with multi-homing consumers. The utility of the consumer who buys exclusively from firm A or exclusively from firm B is given by (2.1) and (2.2) respectively, while the utility of the consumers who multi-home can be expressed as

$$U_m = v + \theta - t|\tilde{x} - a| - t|(1 - b) - \tilde{x}| - p_A - p_B$$

$\theta \in [0, v]$ is the additional utility from purchasing the second good.

The consumer located at x_{AB} is indifferent between buying from firm A exclusively and buying from both firm A and firm B. Hence, the consumers located to the left of x_{AB} are

[14] They assume consumers buy at most one good from each firm.

firm A's exclusive demand. Similar, the consumer located at x_{BA} is indifferent between buying from firm B exclusively and buying from both firm B and firm A. The consumers located to the right of x_{BA} are then firm B's exclusive demand. Furthermore, the consumers located between x_{AB} and x_{BA} are the multi-homing consumers. Consequently, the firms' total demand consist of their exclusive demand and the demand of the multi-homing consumers who buy from both firms.[15]

One important implication of multi-homing, is that prices are strategically independent, as opposed to in single-homing, where the price charged by a firm will impact the competitor's price through a change in demand (Kim and Serfes, 2006 and Anderson et al., 2018). To illustrate the intuition behind this implication, we can look at a marginal decrease in the price of firm A. This will increase the total demand of firm A, but it will not affect firm B's total demand. A consumer who preferred good B will not substitute it for good A, but rather buy good A in addition to good B. In figure 2.3 this implies that x_{BA} moves towards Firm B. Thus, the total demand of firm B remains the same, while the total demand of firm A increases. Since the price reduction of firm A does not affect firm B's total demand, firm B will have no incentive to change its price. In other words, multi-homing cancels out the business stealing effect.

Under single-homing d'Aspremont et al. (1979) found that minimal differentiation is no rational strategy as it intensifies price competition and consequently might eliminate all profits. However, as Kim and Serfes (2006) illustrated, this reasoning may no longer hold under multi-homing as a change in price only affect the total demand of that firm and not the rival. When firms moves closer to the middle the competition will not be intensified, only the amount of multi-homing consumers increase. Hence, minimal differentiation can be a rational strategy to increase the amount of consumers purchasing from both firms. The driving effect behind the firm's tendency to move closer under multi-homing is what Kim and Serfes (2006) call the *aggregate demand creation effect.*

Anderson, Foros, and Kind (2017) investigate the effects of product functionality on prices, profits and the likelihood of multi-purchasing in a one-sided Hotelling model.

[15] The total demand of firm A is then the consumers located left to x_{BA} and the total demand of firm B is $1 - x_{AB}$.

Similarly to Kim and Serfes (2006), they allow consumers to buy two goods but at most one from each firm. From their formulation, where the product functionality measure interacts with the distance-based utility, the benefit from multi-purchasing will depend on the overlapping functionalities.[16] In example, some people value having a Kindle in addition to an iPad, as a Kindle is lightweight, has a long battery life and can feel more like reading an actual book. However, the incremental value of having a Kindle as well as an iPad might vanish if the two products become too similar. The authors capture the potential fall in incremental valuation of the second good by modelling the incremental value as $V_i = q_i - \beta q_0 q_1$ (with $i = 0, 1$). Here $q_i \in [0, 1]$ is the functionality of the good offered by firm i, and $\beta \in [0, 1]$ measures the consumer's benefit of having the same attributes in both goods.

In standard symmetric Hotelling models prices and profits are dependent of only the transportation cost (t) and independent of the quality level. In contrast, the way Anderson et al. (2017) model vertical and horizontal product differentiation lead to symmetric equilibrium prices and operating profits under single-homing that are strictly increasing in transportation cost as well as functionality levels. This is from the fact that an increase in functionality is valued more by higher preference consumers. Furthermore, under multi-purchasing, they discuss the possibility of a hump-shaped relationship equilibrium between prices and functionality. The argument is that if both firms have low initial functionality levels, an increase will clearly benefit the consumers. But as they keep on increasing, the number of functionalities that are shared will be larger, and the benefit from multi-purchasing will vanish. Other things equal will lead to the Bertrand Paradox. Whether there is an actual hump-shaped relationship depends on the consumer's preference for having the same functionality for different variants of a good. Similar to previous research on multi-homing they find that prices are strategically independent, even in their case, where prices are determined by the attributes of both goods. The functionalities offered by the rival determines the demand, not the price.

Armstrong (2006) discusses how the competition in a two-sided market depends on whether an agent chooses to single- or multi-home. In which there are three possible cases,

[16] In contrast to other studies on the same topic, which do not take into account whether consumers care about functionalities being the same or different (Kim & Serfes, 2006).

(i) both groups single-home,

(ii) one group single-home while the other multi-home, and

(iii) both groups multi-home.

The latter might not seem to be very common, as when all agents in one group join both platforms, there will be no need for agents in the other group to do the same. In contrast, several important markets will have one group single-homing and one group multi-homing, which will lead to *competitive bottlenecks*. As an example, consumers might only read one newspaper, while advertisers place ads in all relevant newspapers. Here the multi-homing side has no other choice but to deal with the platform to get access to the single-homing side, giving the platform monopoly power over the multi-homing side. This leads to platforms charging higher prices to the multi-homing side, resulting in ineffective competition. While on the other side, the platforms will have to compete for the single-homing agents through price competition.

The assumption of consumers single-homing in the media market has become more questionable after the arrival of the internet (Athey, Calano, & Gans, 2018). There is an increasing amount of consumers streaming instead of watching linear television, as well as reading news online rather than buying a printed newspaper. Many of the streaming services and online newspapers are ad-financed, making it easier for consumers to switch between platforms, hence multi-homing. This also means consumers will be exposed to advertisements from multiple sources. Anderson et al. (2018) relax the assumption of consumers single-homing in the media market, finding that Armstrong's competitive bottleneck problem disappears when a fraction of consumers' multi-home. Placing an advertisement on a platform will then enable the advertisers to reach both exclusive consumers (single-homers), as well as consumers shared with the other platform (multi-homers). Thus, fundamentally changing the basis of which platforms can charge higher prices and generate most profits from the advertiser side. The platforms can now only charge the value of its exclusive consumers plus the incremental value associated with the shared consumers. This is what Anderson et al. (2018) calls the *incremental value principle*, and the principle holds no matter the consumers' attitude towards advertisement. Since shared consumers typically are worth less than exclusive consumers, platforms may want to differentiate from their rivals to deliver more exclusive "eyeballs" to the advertisers.

Anderson et al. (2019) examines the effect of multi-homing consumers for market performance in a two-sided media market. They allow for dual source financing, meaning the platforms can charge both the consumers and the advertisers. As the purpose of their analysis is to look at incentives for entry and merger they employ a circular model (Salop) instead of the traditional duopoly model (Hotelling).

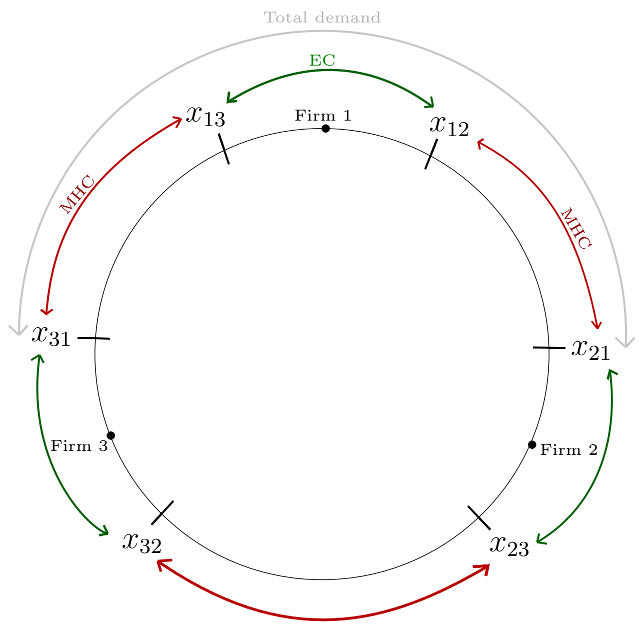

Figure 2.4: *Illustration of Salop's Circular City with multi-homing consumers*

The platforms are symmetrically located around the circle, and illustrated in figure 2.4, are the exclusive consumers (EC) and multi-homing consumers (MHC) for firm 1 with two competing firms ($n = 3$). Here x_{12} is the location of the consumer who is indifferent between buying only from firm 1 and buying from both firm 1 and firm 2.

In line with previous findings, the price in the case of multi-homing consumers is strategically independent. The platform's own pricing behavior does not affect its number of exclusive consumers, only their number of multi-homers. For instance, if firm 1 decreases its price, x_{12} and x_{13} are unaffected, while x_{21} and x_{31} moves clockwise and counterclockwise, respectively. The platforms allow for advertisements, decide a price per ad and the advertisers only place one ad per platform. Similar to Anderson et al.

(2018), they assume that for advertisers, the first impression is worth more than a second impression. Therefore, the platforms can charge the advertisers b per exclusive consumer and σb per multi-homing consumer ($\sigma \in [0, 1]$).[17] They also have some interesting findings in regards to merger under multi-homing, which we will come back to in the next section.

2.4 Merger

When two or more companies fusion their operations to one legal entity and maximise joint profits, it is referred to as a merger. Although there are different types of mergers, we will focus on those characterised as horizontal. A horizontal merger implies a merger between companies that operate within the same industry or market, which most of the time will soften competition. The topic has been extensively researched and the implications for welfare and competition are well known. Therefore, most developed countries have some form of anti-trust legislation monitored by competition authorities. The purpose of such legislation is to ensure effective use of society's resources through promoting competition, thereunder avoiding unfavorable mergers (Konkurranseloven, 2004).[18] There are two anticompetitive effects related to horizontal mergers: unilateral effects and coordinated effects. The first arises when competition is eliminated as a result of a merger, allowing the merged firm to unilaterally exercise market power. The other is when a merger makes it possible for firms post merger to coordinate behavior in a way that softens competition, in example raising the prices.

Even though there exists a vast amount of literature on mergers, it is often in the setting of a one-sided market. Standard economic predictions do not always hold in two-sided markets, due to the fact that the platforms have to balance the interests of two different agents. Thus, it is often possible to observe firms in these industries behaving in ways that would not be optimal for firms in one-sided markets. Chandra and Collard-Welexer (2009) study merger in two-sided markets, in particular, the effects of mergers in the newspaper industry. They present a model which shows that joint ownership of two separate firms actually could lead to lower prices on both sides of the market, compared to if the firms were owned separately. The intuition behind this result,

[17] A third impression is worth nothing.

[18] The exact purpose and wording will vary from country to country.

is that the joint ownership internalises the effect a change in price will have on both firms. As discussed earlier, a newspaper not only value the readers for the direct revenue, but also for the value advertisers place on them. The marginal reader, that is, the reader who will switch from one paper to the other if a price changes, can have a negative or positive effect on the newspapers' profit.[19] If a marginal reader provides a negative value to the newspaper, a duopolist will set a higher price to the readers than a monopolist.[20] To test their conclusion, they examined the consequences of the wave of mergers and ownership changes in the Canadian newspaper industry that took place in the period 1995-1999. The results gave support to the prediction of their model, but it is important to note that there could be other explanations for some of the mergers unrelated to profits.[21]

As mentioned in the previous section, Anderson et al. (2019) analyses the effects of multi-homing consumers on market performance in a two-sided market. They assume that advertisers value a first impression more than a second impression, which entails that the platforms can charge b for exclusive consumers and only σb for multi-homing consumers ($\sigma \in [0, 1]$). When consumers only single-home, the authors show that merger or entry will only affect consumer prices, while the advertiser prices are left unchanged. This is because all consumers are reached once, there is no second impression, thus advertiser prices remain at b. In contrast, entry or merger under multi-homing only impacts the advertiser prices, not consumer prices or other platforms. There are two key properties for this result. Firstly, a platform does not change a rival's (or "sibling" in the case of merger) consumer base when changing it's consumer price. Secondly, while a change in consumer prices does not impact the total consumer base, it changes the fraction of multi-homing or single-homing consumers. Switching a rival's exclusive consumer to a shared consumer gets the firm an incremental value of b, while converting a siblings exclusive consumer to a mutually shared one gets the firm $b(1 + \sigma)$ in place of b. To summarise, multi-homing completely flips the side of the market on which platforms compete.

Another important topic in regards to mergers, that is often overshadowed by the focus on price implications, is the quality and product characteristics. Fan (2013)

[19]If a newspaper prices below marginal cost to the readers, the value of the reader depend on whether or not they generate revenue from the advertisers that outweighs the cost-price margin.

[20]Here the merger leads to a monopoly.

[21]Examples are political motives and empire building.

developed a structural model of newspaper markets, taking into account both the firm's price adjustment and changes in characteristics of the newspapers as a result of a merger. Based on the model, a simulation of a merger between two newspapers in Minneapolis, show that if this merger had occurred, both newspapers would have decreased the quality and content variety as well as raising both prices.[22] In contrast, two out of three competitors would have increased their quality level. This emphasises the importance of including the implications a merger could have on characteristics of the products other than price.

A related study by Brekke et al. (2017) analyses the effects of a horizontal merger in a one-sided market, where firms simultaneously compete in both prices and qualities. The firms in the market face the quality cost function $C_i = cq_iD_i + \frac{k}{2}q_i^2$. The first element is the variable cost, where the cost of investing in quality (cq_i) is dependent on demand (D_i). The second element is the fixed cost capturing that the cost of investing in quality is more costly the higher the initial quality level is. The authors apply a Salop framework with only single-homing consumers, where demand depends on price, quality and distance. Considering three homogeneous firms, where two merge and one stays outside, the merger facilitates coordination of price and quality between the merged firms. From this the authors find three striking results. First, the merged firms reduce qualities and sometimes also prices, while the outside firm increases both price and quality. This is quite different from when firms only compete in either prices or qualities. In their model, if firms were to compete in only prices, a merger would lead to higher prices from both the outside firm and the merged firms. This is due to the merged firms being able to internalise the negative competition externality that existed prior to the merger, allowing them to increase their price. Furthermore, this will lead to a higher demand for the outside firm and its profit will be maximised at a higher price.[23] Contrarily, if the firms only compete in qualities, they find that both firms will reduce their qualities after a merger. The merged firms will decrease their qualities due to the weaker demand effect, which leads to increased demand for the outside firm. As Brekke et al. (2017) has included both fixed and variable cost of quality in their model, the increased demand for the outside firm will increase its marginal cost of quality provision. The outside firm will then respond by

[22] It was blocked by the Department of Justice.

[23] With other words, prices are strategic complements when firms compete in only prices in their model.

decreasing quality.[24]

However, the authors argue that the nature of the strategic interaction changes when firms compete in both prices and qualities. When the firms internalise their own quality and pricing decisions, qualities become strategic substitutes rather than complements. If a rival increases its quality, the direct effects is to increase quality and reduce price due to reduced demand. However, the decrease in price makes it optimal to decrease own quality. Firstly, a lower price leads to higher demand which increases the marginal cost of quality provision. Secondly, a decreased price means a lower profit margin, which means profits are maximised at a lower demand. Both of these makes it optimal to decrease quality. This indirect effect on quality is stronger than than the direct effect from the rival's quality increase, resulting in qualities being strategic substitutes. This explains the changes in qualities of the merged and outside firm after a merger. According to the authors, the merged firms will provide a lower quality to reduce competition along the quality dimension. The response from the outside firm will be to increase quality, due to qualities being strategic substitutes. Furthermore, the increase in quality of the outside firm leaves them with a larger market share which leads to a higher average quality provided in the market after merger.

For prices their results are non-uniform, as they find that the merged firms might actually lower their prices if the demand responsiveness to quality is sufficiently high. That is, if the consumers highly value an increase in quality relative to perceiving the firms as close substitutes.[25] They claim that a high demand responsiveness to quality results in competition mainly occurring along the quality dimension, which will in turn lead to a large reduction in quality for the merged firms. Furthermore, if the indirect effect of own quality on price dominates, it will result in reduced prices.[26] However, the response of the outside firm will regardless be to increase its price. This is due to the effect on outside firm's price from both the increased outside firm's quality and merged firms' qualities being decreased. The decreased qualities of the merged firms leads to higher

[24] In their model qualities are strategic complements if firms only compete in quality.

[25] When the consumers perceive the firms as close substitutes the cost of switching between firms will be low.

[26] Where a decrease in quality leads to lower demand and decreased marginal production cost, which both translates to a lower optimal price.

demand of the outside firm and profits will be maximised at a higher price. Regardless of the non-uniform results for the merged firms prices, the larger market share of the outside firm leads to an increased average price in the market. Consequently, from the results of the quality and price decision after a merger, the authors find that the outside firm always benefits more than the merged firms, which is in line with other literature on the subject. Lastly, due to the non-uniform effects of a merger, the welfare effects are generally ambiguous depending on how elastic quality is, which we will further discuss in the next section.

2.5 Economic Welfare

Economic welfare consists of the aggregated welfare of both the consumers and the producers. Therefore, it can be seen as a measure of how well an economy performs. The welfare of a consumer is often referred to as the consumer surplus (CS), and can be expressed as the willingness to pay for a good minus the price they have to pay for it. By adding up all the individual consumer surpluses we find the total consumer surplus. Furthermore, the producer welfare (or surplus) is the profit the producers make by selling their goods or services to consumers, and the total producer surplus can be found by adding together all the producers' profits in the economy. In our case we have a platform (digital newspapers), advertisers and consumers (readers).

What to include when measuring economic welfare has been debated, and depends on the circumstances and the purpose of use. In the context of most standard economic theory, one expresses economic welfare as the sum of consumer surplus and producer surplus weighted equally. While in the case of anti-trust authorities, there are different practices across the world. In both the EU and US the standard is *consumer welfare* (Konkurransetilsynet (2016); Heyer (2006)). Norway, on the other hand, operated with *total welfare* until it was changed in 2016 harmonising with the EU standard (Konkurransetilsynet, 2016). Thus, the main question is whether one should put more weight on the consumers in such cases when analysing mergers.

Arguments in favor of using the total welfare is that the producer gains will be accounted for, which again can be beneficial for the consumers. One example is that from a consumer's welfare point of view, one would want increased competition to push prices down, but this could lead to less focus on innovation and quality (Heyer (2006); Sørgard (2009)). Same argument can be applied for mergers leading to reduced fixed cost, which in itself (according to economic theory), does not benefit the consumers through lowering the prices. But this could open up for offering more products or increased focus on research and development. Lastly, many consumers are today connected to the companies directly through stocks or funds, therefore, not accounting for the producers, could initially hurt the consumers.

On the contrary, an argument in favor of using only consumer welfare is that consumers have less power in regards to opposing an unwanted act compared to the producers. Thus, the anti-trust authorities should be the voice of the consumers, as the producers might have a stronger position in terms of lobbying (Kennedy, 2018). Another good argument appears in the context of how to evaluate the effects of a merger, since it often is asymmetric information between the merging firms and the authorities. Therefore, the weight should be put in favor of the consumers. As the main purpose of economic welfare in our model is to analyse merger implications from a pure theoretical point of view, we put even weight on all parties. This leaves us with the welfare expression $W = PS + AS + CS$.

Brekke et al. (2017) analyse the consumer and total welfare change from a horizontal merger when firms simultaneously compete in prices and qualities. As their results for how merger affects prices and qualities are ambiguous, so are their results for the welfare change. Even though consumer surplus is strictly decreased, they strikingly find that the total welfare might be improved as a result of a merger if demand responsiveness to quality is sufficiently strong.

3 The Model

In this section we examine, through a theoretical model, the effects of a merger in a two-sided media market. Each platform (digital newspapers) offers access to a single media product, and choose a level for both their consumer price and quality. The platforms have two sources of income, they sell access to their product to the consumers (readers), and they sell the consumers' "eyeballs" to the advertisers. We have two versions of the model. In the first version, we consider the case where consumers single-home, that is, only purchase access to one platform. In the second version, we let consumers multi-home, meaning they are allowed to purchase access to two different platforms. We will first present the basics of the model, and then report our equilibrium outcomes, both in the case of symmetric competition and in the case of a merger.

3.1 Single-Homing

3.1.1 Consumer Utility and Demand

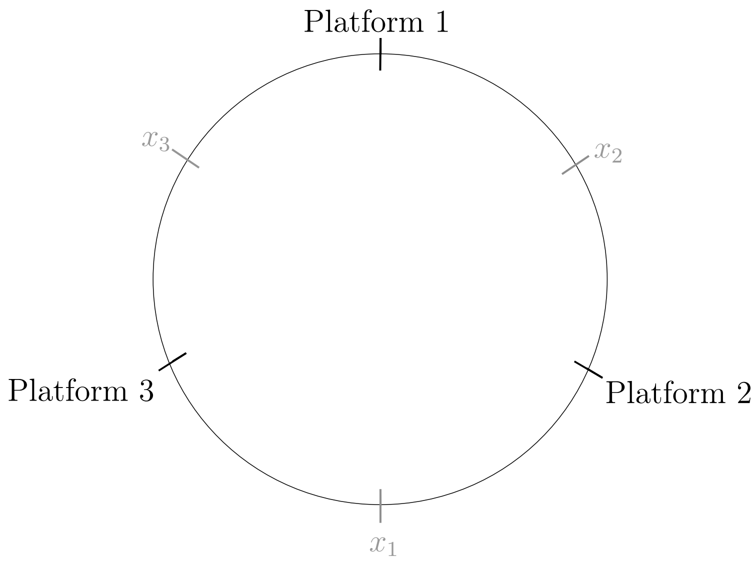

Figure 3.1: *Location of platforms and single-homing consumers*

We use the Salop circle from Anderson et al. (2019) as a basis for our model. To ensure at least duopolistic competition after a merger, we allow for $n \geq 3$ platforms.[27] The

[27]As mergers that result in monopoly are generally prohibited by anti-trust authorities and almost never observed in practice (Brekke et al., 2017).

platforms are equidistantly located on the circle, with circumference equal to 1 (see figure 3.1 for an illustration of $n = 3$ platforms). We assume for now that each consumer buys access to one and only one of the paid digital newspapers. Consumers care about prices, quality, and how close the content of the digital newspaper is to their own preferences.

In our model the consumers are ad neutral. This is first and foremost to simplify, but also because we focus on digital newspapers. That is a part of the media market where we do not expect the effect of the advertisements to be as direct and strong as one would in other parts (Anderson et al., 2019). When consumers watch television they are forced to watch advertisements if they do not switch channels, in contrast to digital newspapers where the ads usually pop up on the side.

The consumers are uniformly distributed around the circle, and the utility function of a consumer located at x is given by

$$u_i = v(1 + q_i) - t|x_i - x| - p_i \tag{3.1}$$

$v > 0$ is the gross utility from having access to a digital newspaper, while p_i and q_i are the consumer price charged and quality offered by platform i $(= 1, ..., n)$, respectively. t is the disutility measure for the consumer located at x from having to travel to the location x_i of the newspaper. The total transportation cost is given by $t|x_i - x|$. When t goes toward zero, the consumer is less heterogeneous and perceive the newspapers as closer substitutes. Hence, the transportation cost can be interpreted as the disutility faced by the consumers from buying access to a digital newspaper that does not exactly match their preferences.

The location of the consumer who is indifferent between buying access from platform i and j is then given by

$$v(1 + q_i) - tx - p_i = v(1 + q_j) - t|\frac{1}{n} - x| - p_j$$

Similarly, the location of the consumer who is indifferent between buying access from platform i and k is given by

$$v(1+q_i) - tx - p_i = v(1+q_k) - t|\frac{1}{n} - x| - p_k$$

where $i \neq j \neq k$.

When consumers maximise their utility, the demand faced by platform i is

$$D_i = \frac{1}{n} + \frac{v(2q_i - q_j - q_k) - 2p_i + p_j + p_k}{2t} \tag{3.2}$$

When t is high, the consumer will have stronger preferences in regards to which platform to purchase access from, and will be less affected by the consumer prices and qualities of the products offered in the market. If in addition, the consumer have a low valuation of quality (low v), they will be even less affected by the qualities offered. Hence, the demand responsiveness to quality is low (high) if the value of v is low (high) relative to t.

3.1.2 Platforms and Advertisers

The media platforms charge consumers for access to the digital newspapers, and advertisers for the attention of these consumers. We assume that the marginal production cost is equal to zero. The platforms can invest in quality, for example journalism or better digital features. The associated cost of these quality investments is $\frac{1}{2}q_i^2$. The convexity of this investment cost captures the assumption that increasing quality is more expensive the higher the initial quality level is. Platforms charge advertisers b per ad for each pair of "eyeballs". Following Anderson et al. (2019) we assume that advertisers only place one ad per platform, and demand for ads is perfectly elastic with a mass A of homogeneous advertisers equivalent to 1. The profit of platform i is then given by

$$\pi_i = (p_i + b)D_i - \frac{1}{2}q_i^2 \tag{3.3}$$

3.1.3 Equilibrium Outcomes

In this model we look for an equilibrium where the consumer price and quality decisions are made simultaneously. This implies that the platforms do not commit to a fixed level of quality before the pricing decision, or vice versa. The platforms choose p_i and q_i to maximise (3.3), which leaves us with the following first order conditions[28]

$$\begin{aligned} \frac{\partial \pi_i}{\partial p_i} &= D_i + (p_i + b)\frac{\partial D_i}{\partial p_i} = 0 \\ \frac{\partial \pi_i}{\partial q_i} &= (p_i + b)\frac{\partial D_i}{\partial q_i} - q_i = 0 \end{aligned} \tag{3.4}$$

From this we can derive platform $i's$ best response functions for both consumer price and quality

$$p_i(p_j, p_k, q_i, q_j, q_k) = \frac{t}{2n} + \frac{v(2q_i - q_j - q_k) + (p_j + p_k)}{4} - \frac{b}{2} \tag{3.5}$$

$$q_i(p_i) = \frac{v(p_i + b)}{t} \tag{3.6}$$

We can see that consumer prices are decreasing in rivals' qualities, while qualities are independent of rivals' consumer prices ($\frac{\partial p_i}{\partial q_{-i}} > 0$ and $\frac{\partial q_i}{\partial p_{-i}} = 0$). Ceteris paribus, a consumer price increase by one platform has no effect on the quality provision of the competing platforms. A quality increase, however, leads to a lower demand for competing platforms and they will, keeping all else fixed, decrease their consumer price. As in standard literature, consumer prices are strategic complements between competing platforms ($\frac{\partial p_i}{\partial p_{-i}} > 0$). This is simply because, if one platform increases it's consumer price, the demand of the competing platforms increase. Consequently, the profits of the competing platforms will be maximised at a higher consumer price. More surprisingly, *qualities are strategically independent between platforms* ($\frac{\partial q_i}{\partial q_{-i}} = 0$). An increase in quality of one platform will lead to a decrease in demand of the competing platforms. But since this in turn will have no other direct implications for their profits, they should have no

[28] The second order conditions are satisfied: $\frac{\partial \pi_i^2}{\partial p_i^2} = -\frac{2}{t} < 0$ and $\frac{\partial \pi_i^2}{\partial q_i^2} = -1 < 0$. The Hessian is $\begin{pmatrix} \frac{\partial \pi_i^2}{\partial p_i^2} & \frac{\partial \pi_i^2}{\partial p_i \partial q_i} \\ \frac{\partial \pi_i^2}{\partial q_i \partial p_i} & \frac{\partial \pi_i^2}{\partial q_i^2} \end{pmatrix} = \begin{pmatrix} -\frac{2}{t} & 0 \\ 0 & -1 \end{pmatrix} > 0$, which is negative definite for $t > 0$.

incentives to change their qualities.

However, here we are not taking into account the nature of the strategic interaction when firms choose consumer price and quality simultaneously (Brekke et al., 2017). By isolating the decisions within platforms without looking at strategic responses by the competitors, we see that $\frac{\partial p_i}{\partial q_i} > 0$ and $\frac{\partial q_i}{\partial p_i} > 0$. When a platform increases it's quality it will lead to a higher demand, and their profit will then be maximised at a higher consumer price. From an increase in consumer price, the platform will have a higher profit margin, which makes more valuable to have a higher demand, making it optimal to increase quality provision.

By solving (3.5) and (3.6) simultaneously and with respect to q_i and p_i we can then internalise the decisions for quality and consumer price within each platform

$$p_i(p_j, p_k, q_j, q_k) = \frac{2t^2}{2(2t - v^2)n} + \frac{2b(v^2 - t) + t(p_j + p_k - v(q_j + q_k))}{2(2t - v^2)} \tag{3.7}$$

$$q_i(p_j, p_k, q_j, q_k) = \frac{vt}{(2t - v^2)n} + \frac{v(p_j + p_k + 2b - (q_j + q_k))}{2(2t - v^2)} \tag{3.8}$$

When we take this optimal consumer price adjustment into account, it alters the strategic interaction between qualities. From qualities being strategically independent, they are now strategic substitutes. An increase in a rival's quality leads to a decrease in your demand, which makes it optimal to decrease consumer price. The decreased consumer price results in a lower profit margin, and then the profit is maximised at a lower demand. To decrease demand, the platform will decrease its quality. In summary we have the following

Proposition 1 (Single-homing). *In this media market*

(i) consumer prices are strategic complements $(\partial p_i(p_{-i}, q_{-i})/\partial p_{-i} > 0)$

(ii) qualities are strategic substitutes $(\partial q_i(q_{-i}, p_{-i})/\partial q_{-i} < 0)$

The strategic interaction in our single-homing model when platforms compete simultaneously in consumer prices and qualities resemble the ones found in Brekke et al. (2017). However, if firms were to compete solely along the quality-dimension, they find qualities to be strategic complements, while we find strategic independence.[29] The difference is due to their model specifications, where they include quality cost that depends on demand.

When we simultaneously solve the three pairs of best response functions, given by (3.7) and (3.8), we obtain the following symmetric equilibrium consumer prices, qualities and profits under single-homing[30]

$$\begin{aligned} p^{sh} &= \frac{t}{n} - b \\ q^{sh} &= \frac{v}{n} \\ \pi^{sh} &= \frac{1}{2n^2}\left(2t - v^2\right) \end{aligned} \tag{3.9}$$

The equilibrium profit is independent of b, as we have assumed that the market is fully covered.[31] In contrast to Brekke et al. (2017), our equilibrium consumer price is decreasing in ad-price b, due to the two-sided nature of our model. Similarly as in Anderson et al. (2019), b can be seen as a "negative" marginal cost on consumer price. If the value of selling the attention of the consumers increase, the platforms will lower the consumer price to increase the number of eyeballs sold to the advertisers. Note that we need $b \leq \frac{t}{n}$ for this to be an equilibrium, which we impose for the remainder of our thesis.

3.1.4 Merger of Two Platforms

We will now consider a case with $n = 3$ platforms, where two of the platforms merge and the third is left outside. We assume that a merger does not change the number of products offered in the market, nor the location or number of platforms. Rather, it leads to coordination on the price and quality decisions between the merging platforms.

[29] From (3.6)

[30] See calculations of the equilibrium profit in appendix A1.1.

[31] Assuming that the consumers who is indifferent between two platforms strictly prefers to participate, which is guaranteed through the gross utility from having access to a platform being sufficiently high.

The merged platforms choose prices and qualities, to maximise the following joint profit

$$\pi_{1+2} = \pi_1 + \pi_2 = (p_1 + b)D_1 - \frac{1}{2}q_1^2 + (p_2 + b)D_2 - \frac{1}{2}q_2^2 \tag{3.10}$$

The first order conditions are[32]

$$\begin{aligned} \frac{\partial \pi_{1+2}}{\partial p_1} &= D_1 + (p_1 + b)\frac{\partial D_1}{\partial p_1} + (p_2 + b)\frac{\partial D_2}{\partial p_1} = 0 \\ \frac{\partial \pi_{1+2}}{\partial q_1} &= (p_1 + b)\frac{\partial D_1}{\partial q_1} - q_1 + (p_2 + b)\frac{\partial D_2}{\partial q_1} = 0 \end{aligned} \tag{3.11}$$

The outside platform chooses prices and quality to maximise its profit. The profit of the outside platform is equal to the one before merger (equal to (3.3)) with the related first order conditions from (3.4). The best response functions for consumer prices and qualities of the merged and outside platform are[33]

$$p_1 = p_2 = p_m = \frac{t}{3} + \frac{v(q_m - q_o) + p_o - b}{2} \tag{3.12a}$$

$$q_1 = q_2 = q_m = \frac{(p_m + b)v}{2t} \tag{3.12b}$$

$$p_3 = p_o = \frac{t}{6} + \frac{v(q_o - q_m) + p_m - b}{2} \tag{3.13a}$$

$$q_3 = q_o = \frac{(p_o + b)v}{t} \tag{3.13b}$$

p_o and q_o denote the consumer price and quality set by the outside platform, while p_m and q_m are the consumer prices and qualities set by the merged platforms. When solving (3.12a) - (3.13b) simultaneously we obtain the following asymmetric equilibrium under single-homing[34]

[32] The second order conditions are satisfied: $\frac{\partial \pi_{1+2}^2}{\partial p_1^2} = -\frac{1}{t} < 0$ and $\frac{\partial \pi_{1+2}^2}{\partial q_1^2} = -1 < 0$. The Hessian is $\begin{pmatrix} \frac{\partial \pi_{1+2}^2}{\partial p_1^2} & \frac{\partial \pi_{1+2}^2}{\partial p_1 \partial q_1} \\ \frac{\partial \pi_{1+2}^2}{\partial q_1 \partial p_1} & \frac{\partial \pi_{1+2}^2}{\partial q_1^2} \end{pmatrix} = \begin{pmatrix} -\frac{1}{t} & 0 \\ 0 & -1 \end{pmatrix} > 0$, which is negative definite for $t > 0$.

[33] See calculations for best response functions for the merged and outside platform in appendix A1.1.

[34] See calculations of the asymmetric equilibrium demands and profits in appendix A1.1.

$$\begin{aligned}
p_m^{sh} &= \frac{2t(5t-3v^2)}{9(2t-v^2)} - b \\
q_m^{sh} &= \frac{v(5t-3v^2)}{9(2t-v^2)} \\
\pi_m^{sh} &= \frac{(5t-3v^2)^2(4t-v^2)}{162(2t-v^2)^2} \\
D_m^{sh} &= \frac{5t-3v^2}{9(2t-v^2)}
\end{aligned} \tag{3.14}$$

$$\begin{aligned}
p_o^{sh} &= \frac{t(8t-3v^2)}{9(2t-v^2)} - b \\
q_o^{sh} &= \frac{v(8t-3v^2)}{9(2t-v^2)} \\
\pi_o^{sh} &= \frac{(8t-3v^2)^2}{162(2t-v^2)} \\
D_o^{sh} &= \frac{8t-3v^2}{9(2t-v^2)}
\end{aligned} \tag{3.15}$$

For this to be an equilibrium we need $t > \frac{3}{5}v^2$.

For a merger to be profitable in this media market, the joint profit of the merged platforms need to be higher after merger.

Comparing (3.14) to (3.9) we have

$$\begin{aligned}
2\pi_m^{sh} - 2\pi^{sh} &= \frac{(5t-3v^2)^2(4t-v^2)}{81(2t-v^2)^2} - \frac{1}{9}\left(2t-v^2\right) \\
&= \frac{t(7t-4v^2)(4t-3v^2)}{81(2t-v^2)^2}
\end{aligned} \tag{3.16}$$

which is positive for $t > \frac{3}{4}v^2$, we provide proof in appendix A1.1. From (3.16) we can now note the following.

Proposition 2 (Single-homing). *A merger is profitable in this media market when* $t > \frac{3}{4}v^2$, *and unprofitable otherwise.*

As we would not expect an unprofitable merger to occur, we impose the merger profitability condition in this media market and restrict attention to only profitable mergers. We make use of the profitability condition to compare the pre-merger symmetric equilibrium with $n = 3$ platforms from (3.9) and the asymmetric equilibrium from (3.14) and (3.15). This yields

$$\begin{aligned} q_m^{sh} - q^{sh} &= -\frac{vt}{9(2t - v^2)} \quad < 0 \\ q_o^{sh} - q^{sh} &= \frac{2vt}{9(2t - v^2)} \quad > 0 \\ p_m^{sh} - p^{sh} &= \frac{t(4t - 3v^2)}{9(2t - v^2)} \quad > 0 \\ p_o^{sh} - p^{sh} &= \frac{2t^2}{9(2t - v^2)} \quad > 0 \end{aligned} \tag{3.17}$$

$$\bar{q}_{after}^{sh} - \bar{q}_{before}^{sh} = (2q_m^{sh} D_m^{sh} + q_o^{sh} D_o^{sh}) - 3q^{sh} D^{sh} = \frac{2\,vt^2}{27\,(2\,t - v^2)^2} \quad > 0 \tag{3.18}$$

As we can see, a merger leads to an increase in the consumer price offered by both the merged platforms and the outside platform. In contrast, the merger implications for quality levels are not uniform. The outside platform will increase its quality, while the merged platforms decrease their quality. The average quality provided in the market (denoted $\bar{q}_r^{sh}$, where $r = before, after$), however, is increased after the merger. With other words, the average consumer experiences a higher quality after merger.

The two merged platforms internalise the negative competition externality that existed between them prior to the merger, leading to joint profits that are maximised at higher consumer prices. Now that the merged platforms need to take into account each others demand, some of the positive demand effect of increasing own quality is canceled out by the negative demand effect of the other. As the cost of quality stays the same, the joint profits are maximised at a lower quality level than before the merger.[35] The direct effect of these consumer price and quality decisions will trigger the outside platform to increase its consumer price and quality. This is a result of consumer prices being

[35] Cost of quality stays the same, as the merger do not alter the cost of quality.

strategic complements and qualities being strategic substitutes. The latter explains why the quality level provided from the outside platform is higher after the merger. Moreover, the outside platform profits more from the merger than the merged platforms, which is in accordance with previous literature. We can summarise these results as the following.

Proposition 3 (Single-homing). *In this media market with 3 competing digital newspapers, a merger leads to*

(i) higher consumer prices and lower qualities offered by the merged platforms

(ii) higher consumer price and quality offered by the outside platform

(iii) higher average consumer price and quality provision in the market

These results are similar to the ones found by Brekke et al. (2017). When firms compete in consumer prices and qualities simultaneously, their interesting find is that the merged firms reduce qualities and sometimes also consumer prices, while the outside firm increases both consumer price and quality. In contrast to Brekke et al. (2017), the results of our model are that merged platforms will strictly increase their consumer prices. In our model the internalisation of the negative competition externality that existed between the merged platforms prior to the merger outweighs the effect of lower quality on the platform's own consumer price. Profits of the merged platforms are then maximised at a higher consumer price than before the merger. Brekke et al. (2017) found that the average quality provided in the market increases from a merger, which we also obtain as a result from our model. Our asymmetric quality effect of a merger is also reflected in the results of Fan (2013) simulation of mergers in the US daily newspaper market. Here she found that the merged firms would decrease their quality, while two out of three competitors would increase theirs.

3.2 Multi-Homing

3.2.1 Consumer Utility and Demand

In this version of the model we relax the assumption about consumers only purchasing access to a single platform. We now allow consumers to multi-home, that is, to buy access to two platforms.

Remember that the utility of a consumer that buys access to only platform i located at x is

$$u_i = v(1 + q_i) - t|x_i - x| - p_i$$

where x_i is the location of platform i.

If the consumer decides to multi-home, their recognised value of having access to platform i might be lower than the value recognised by a consumer who decides to only buy access to platform i. As in the model of Anderson et al. (2017) and Anderson et al. (2019), we assume that the incremental value for a multi-homing consumer who decides to buy access to platform i in addition to platform j is given by

$$u_{ji} = [v(1 + q_j) - t|x_j - x_{ji}|]\, \gamma - p_j, \quad \gamma \in [0, 1]$$

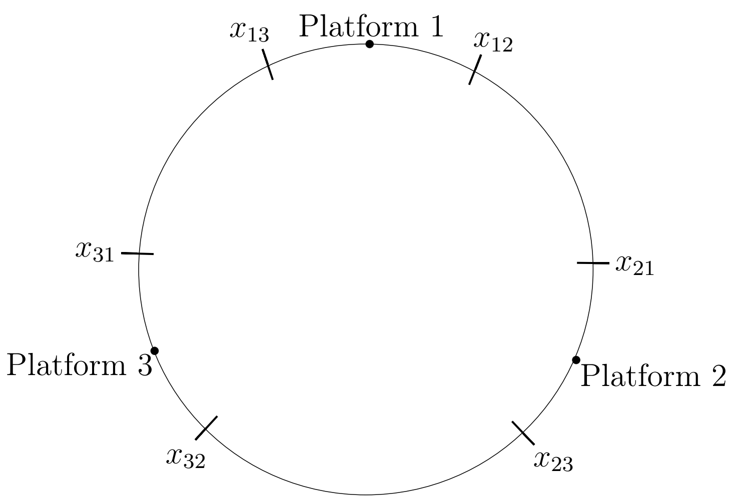

Figure 3.2: *Location of platforms and single-homing and multi-homing consumers*

To find the location of the consumer who is indifferent between buying access to only platform 1 and buying access to platform 2 in addition to 1, we need to solve $u_1 = u_1 + u_{12}$ which is equivalent to solving $u_{12} = 0$ (see appendix A1.2 for calculations)

$$x_{12} = \frac{1}{n} - \frac{1}{t}\left[v(1+q_2) - \frac{p_2}{\gamma}\right] \tag{3.19}$$

Similarly, to find the location of the consumer who is indifferent between buying only from Platform 1 and buying from both platform 1 and the competitor on the other side of the market, we need to solve $u_{1n} = 0$ (see appendix A1.2 for calculations)

$$x_{1n} = \frac{n-1}{n} + \frac{1}{t}\left[v(1+q_n) - \frac{p_n}{\gamma}\right] \tag{3.20}$$

We can then find the number of single-homing consumers for platform 1 which are located between x_{12} and x_{1n} (depicted in the figure 3.2) by solving $x_{12} + (1 - x_{1n})$. Using (3.19) and (3.20) we find the single-homing consumers for platform 1 to be[36]

$$x_i^{sh} = \frac{2}{n} - \frac{1}{t}\left[v(2+q_j+q_k) - \frac{(p_j+p_k)}{\gamma}\right] \tag{3.21}$$

We see that, the more heterogeneous consumers, the more single-homing consumers will be on the platform (from $\frac{\partial x_i^{sh}}{\partial t} > 0$). The number of single-homing consumers for platform i is decreasing in the number of platforms. It is decreasing in the quality levels and increasing in the consumer prices set by the two closest competitors, while the platform is not able to affect it's own amount of single-homing consumers through changing its consumer price or quality.[37]

The total demand of platform 1 is then the consumers located in the interval from platform 1 to x_{21} and to x_{31} in figure 3.2. We use the same approach for finding x_{21} and x_{31} as we used for (3.19), by solving $u_{21} = 0$ and $u_{31} = 0$, which yields $D_1 = \frac{2}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right]$.

We then have the following total demand for platform i (see appendix A1.2 for calculations)

[36] See appendix A1.2 for detailed calculations.
[37] Which is the same as in the model of Anderson et al. (2019).

$$D_i = \frac{2}{t}\left[v(1+q_i) - \frac{p_i}{\gamma}\right] \tag{3.22}$$

We see that the total demand is unaffected by the closest rivals consumer prices and qualities as well as the number of platforms in the market. It is only affected by own consumer pricing and quality decisions.

Furthermore, we make use of (3.21) and (3.22) to find the number of multi-homing consumers on platform i to be

$$x_i^{mh} = D_i - x_i^{sh} = \frac{1}{t}\left[v(2q_i + q_j + q_k + 4) - \frac{(2p_i + p_j + p_k)}{\gamma}\right] - \frac{2}{n} \tag{3.23}$$

From this we see that, the more heterogeneous consumers are, the less multi-homing consumers will exist in the market (from $\frac{\partial x_i^{mh}}{\partial t} < 0$).

Similarly as in Anderson et al. (2019), we can see from the different demands that *the strategic interaction between competing platforms drastically change when some of the consumer in the market multi-home.* Own pricing and quality decisions no longer affect the number of single-homing consumers. It only affects the platform's number of multi-homing consumers and its total demand, while it is the decisions of the two closest rivals that affect the number of single-homing consumers of that platform.

Specifically, if platform 1 increases its consumer price it will make the indifferent consumers located at x_{31} and x_{21} move closer to platform 1, while the location of the indifferent consumer at x_{13} and x_{12} is unaffected. This implies the same number of single-homing consumer but less multi-homing consumers and total demand. In contrast, if platform 3 (2) increases its consumer price, the indifferent consumer located at x_{31} (x_{21}) is unaffected, while x_{13} (x_{12}) will move closer to platform 3 (2). Then the total demand and number of multi-homing consumers of platform 1 stays the same, while the number of single-homing consumers on the left (right) side of platform 1 increases.

Another interesting observation from (3.21)-(3.23) is that only the single-homing and multi-homing demand is dependent of the number of platforms in the market, while the total demand is independent of n. This is because the incremental value of platform i is unaffected by both the number of platforms in the market and of the consumer prices charged by the rival (Anderson et al., 2019). When an additional platform enters the market, it does not affect the total demand of platform i, it rather reduces the number of single-homing consumers and increase the number of multi-homing consumers of platform i. We can now state the following

Proposition 4 (Multi-homing)**.** *In this media market with multi-homing consumers, we have that*

(i) single-homing demand is

- *decreasing in number of platforms in the market* ($\frac{\partial x_i^{sh}}{\partial n} < 0$)
- *independent of own consumer price and quality* ($\frac{\partial x_i^{sh}}{\partial q_i} = 0$, $\frac{\partial x_i^{sh}}{\partial p_i} = 0$)

(ii) total demand is

- *independent of number of platforms in the market* ($\frac{\partial x_i^{sh}}{\partial n} = 0$)
- *independent of qualities and consumer prices of the competitors* ($\frac{\partial x_i^{sh}}{\partial q_{-i}} = 0$, $\frac{\partial x_i^{sh}}{\partial p_{-i}} = 0$)

(iii) multi-homing demand that is

- *increasing in number of platforms in the market* ($\frac{\partial x_i^{sh}}{\partial n} > 0$)
- *increasing in the qualities of the two closest competitors* ($\frac{\partial x_i^{sh}}{\partial q_{-i}} > 0$)
- *decreasing in the consumer prices of the two closest competitors* ($\frac{\partial x_i^{sh}}{\partial p_{-i}} < 0$)

The impacts on the different demands from a change in consumer price and the number of platforms is in line with the findings of Anderson et al. (2019). Our contribution is to add quality as a decision variable and to our knowledge, this has not been included in this setting before. Own quality has a positive effect on demand whenever own consumer price effect is negative, while they are concurrently independent. Interestingly, the changes in demand from allowing consumers to multi-home, lead to quite different strategic interactions between competing platforms compared to when there are only single-homing consumers in the market.

3.2.2 Platforms and Advertisers

The media platforms can charge both the consumers for access, and the advertisers for the attention of these consumers. By placing advertisement on a platform the advertisers will be able to reach both single-homing and multi-homing consumers. Following the principle of incremental pricing from Anderson et al. (2018) and Anderson et al. (2019), we assume that a platform can charge b for single-homing consumers and only ϕb for multi-homing consumers, with $\phi \in [0, 1]$. In accordance with the first version of the model, the platforms choose a level for both prices and qualities, where the associated quality investment cost is $\frac{1}{2}q_i^2$. The profit of platform i is then

$$\pi_i = p_i D_i + b x_i^{sh} + \phi b x_i^{mh} - \frac{1}{2}q_i^2 \tag{3.24}$$

3.2.3 Equilibrium Outcomes

Similar to the other version of the model, we look for an equilibrium where the pricing and quality decisions are made simultaneously. The platforms choose p_i and q_i to maximise (3.24). The first order conditions are given by[38]

$$\begin{aligned} \frac{\partial \pi_i}{\partial p_i} &= D_i + p_i \frac{\partial D_i}{\partial p_i} + \phi b \frac{\partial x_i^{mh}}{\partial p_i} = 0 \\ \frac{\partial \pi_i}{\partial q_i} &= p_i \frac{\partial D_i}{\partial q_i} + \phi b \frac{\partial x_i^{mh}}{\partial q_i} - q_i = 0 \end{aligned} \tag{3.25}$$

Platform $i's$ best response functions for both consumer price and quality is then the following[39]

$$p_i(q_i) = \frac{1}{2}\left[\gamma v(1 + q_i) - \phi b\right] \tag{3.26}$$

$$q_i(p_i) = \frac{2v}{t}\left[p_i + \phi b\right] \tag{3.27}$$

[38]The second order conditions are satisfied: $\frac{\partial \pi_i^2}{\partial p_i^2} = -\frac{4}{\gamma t} < 0$ and $\frac{\partial \pi_i^2}{\partial q_i^2} = -1 < 0$. The Hessian is $\begin{pmatrix} \frac{\partial \pi_i^2}{\partial p_i^2} & \frac{\partial \pi_i^2}{\partial p_i \partial q_i} \\ \frac{\partial \pi_i^2}{\partial q_i \partial p_i} & \frac{\partial \pi_i^2}{\partial q_i^2} \end{pmatrix} = \begin{pmatrix} -\frac{4}{\gamma t} & 0 \\ 0 & -1 \end{pmatrix} > 0$, which is negative definite for $t > 0$ and $\gamma > 0$.

[39]We derive the best response functions in appendix A1.2

These best response functions illustrate that, when there are multi-homing consumers in the market, the strategic interaction between competing platforms drastically change compared to when there are only single-homing consumers. Now both consumer prices and qualities are *strategically independent between competing platforms* ($\frac{\partial p_i}{\partial p_{-i}} = 0$ and $\frac{\partial q_i}{\partial q_{-i}} = 0$). As consumer prices are no longer dependent on rivals' qualities, the rivals can no longer affect the platform's choice of either consumer price or quality.

The strategic independence of consumer prices and qualities is explained by consumers having the opportunity to buy from their second-most preferred platform in addition to their most preferred.[40] When a platform decrease its consumer price (quality), the total demand of that platform increases. This increase comes from consumers who previously only purchased access to the competing platform, now purchase access to the platform with the decreased consumer price as well. Hence, only the ratio of single-homing and multi-homing consumers of the competing platforms are affected, leaving their total demand unchanged. The profit of the competing platforms will then be lower from selling more of the less valuable "eyeballs" to the advertisers. Their unchanged total demand and inability to affect their number of single-homing consumers, leaves them with no incentives to change their consumer price (quality) to the consumers.

However, when there are multi-homing consumers in the market, the relationship between consumer price and quality within each platform remains the same as when there are only single-homing consumers. As with only single-homing consumers, if a platform increases it's consumer price, the profit margin becomes higher, making it more valuable with higher demand which can be obtained by increasing their quality. The other way around, if a platform increases its quality, the demand increases, meaning that their profits are maximised at a higher consumer price. We can now state the following

Proposition 5 (Multi-homing). *In this media market with multi-homing consumers, consumer prices and qualities are strategically independent between competing platforms* ($\frac{\partial p_i}{\partial p_{-i}} = 0$ *and* $\frac{\partial q_i}{\partial q_{-i}} = 0$)

[40] Rather than having to choose between them.

The fundamental result of strategic independence of consumer prices under multi-homing, is in accordance with previous literature (Kim and Serfes, 2006 and Anderson et al., 2019). However, to our surprise, we have not found existing literature that study price and quality decisions with multi-homing consumers. This makes the strategic independence of qualities from multi-homing consumers presumably a new finding for this type of market.

By solving (3.26) and (3.27) simultaneously, we obtain the following symmetric equilibrium consumer prices, qualities, profits and total demand[41]

$$\begin{aligned} p^{mh} &= \frac{\phi b(2\gamma v^2 - t) + t\gamma v}{2(t-\gamma v^2)} \\ q^{mh} &= \frac{v(\gamma v + \phi b)}{t - \gamma v^2} \end{aligned} \tag{3.28}$$

$$\pi^{mh} = \frac{(n - 4\,b + 4\,\phi b)\,v^2\gamma^2 + (4\,t\,(b - \phi b) - 2\,v\,(b - 2\,\phi b)\,n)\,\gamma - n\phi b\,(2\,b - 3\,\phi b)}{2\,n\gamma\,(t - \gamma\,v^2)} \tag{3.29}$$

$$D^{mh} = \frac{\gamma v + \phi b}{\gamma(t - \gamma v^2)} \tag{3.30}$$

For this to be an equilibrium we need $t > \gamma v^2$, which we assume for the remainder of our analysis.

Both the equilibrium qualities and consumer prices are independent of the number of platforms in the market, which implies that if an entrant was to set up another platform in the market, it will not affect either consumer prices or qualities. The equilibrium qualities are strictly increasing in the value of selling "eyeballs" of the multi-homing consumers to the advertisers ($\frac{\partial p^{mh}}{\partial \phi b} > 0$). From (3.23) we see that an increase in quality will lead to more multi-homing consumers. Hence, when the value of selling access to these consumers increase, the platforms will want to increase the number of multi-homing consumers by increasing their quality levels. The equilibrium consumer prices, on the other hand, are not uniformly affected by ϕb.[42] The platform can decrease their consumer price to attract more multi-homing consumers but if there are already a large portion of multi-homing consumers in the market (t is small), the increase in ϕb has less effect than

[41] See the appendix A1.2 for calculations of equilibrium total demand and profit.
[42] It is only decreasing if $t > 2\gamma v^2$.

when there are a sufficiently large portion of single-homing consumers in the market (t is large).

With n platforms, we can use (3.21) - (3.23) and (3.28) with (3.30) to find the number of multi-homing and single-homing consumers of each platform (see appendix A1.2 for calculations)

$$\begin{aligned} x^{sh} &= \frac{2}{n} - D^{mh} \\ x^{mh} &= 2\left[D^{mh} - \frac{1}{n}\right] \end{aligned} \tag{3.31}$$

From this we can see that we have no single-homing consumers in the market when $D^{mh} = \frac{2}{n}$ and no multi-homing consumers when $D^{mh} = \frac{1}{n}$. We have already in the first version of the model looked at the case where we only have single-homing consumers and advertisers that multi-home. It is important to note that, if all consumers were to multi-home, the advertisers no longer have incentives to multi-home, as they can reach all the consumers by placing ads on only one platform (Armstrong, 2006). Hence, in this version of the model, where we assume that advertiser multi-home, we would expect that consumers partially multi-home ($D^{mh} \in \left\langle \frac{1}{n}, \frac{2}{n} \right\rangle$).

3.2.4 Merger under Multi-Homing

The striking result of strategic independence between consumer prices and qualities of the competing platforms under multi-homing, leaves us with the impression that platforms may no longer have incentives to change either consumer prices or qualities after a merger.[43] On the contrary, a merger under multi-homing enables the two merged platforms to charge the advertisers a higher price $b(1 + \phi)$, as they now have full control over the consumers they share between them (depicted in figure 3.3). Remarkably, *the existence of multi-homing consumers flips competition entirely to the other side of the market* (Anderson et al., 2019).

[43]Where a merger entails that platforms cooperate on the price and quality decisions, not changing the number of platforms or products in the market.

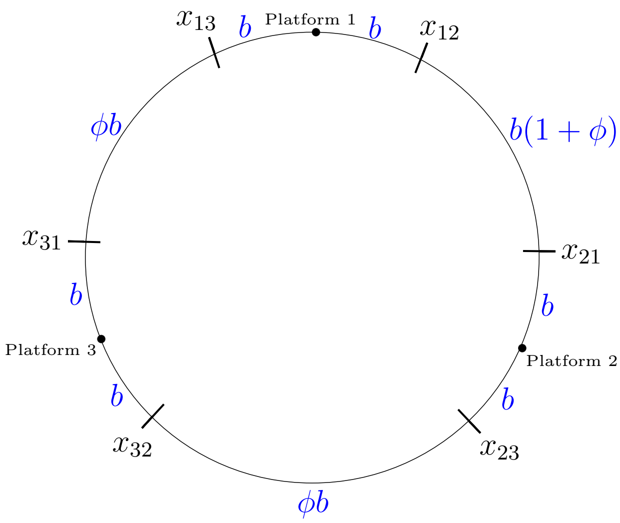

Figure 3.3: *Platforms charge to advertisers after a merger*

Suppose that platform 1 and platform 2 decide to merge. Then the shared consumers between them will be the consumers located between x_{21} and x_{12}. The number of shared consumers between the merged platforms is then[44]

$$x_{21} - x_{12} = \frac{1}{t}\left[v(2 + q_1 + q_2) - \frac{p_1 + p_2}{\gamma}\right] - \frac{1}{n} \tag{3.32}$$

Hence, the merged platforms may capture $b(1+\phi)(x_{21} - x_{12})$ from selling the attention of these consumers to the advertisers. They will choose consumer prices and qualities to maximise the joint profit of the two platforms, which can be written as

$$\begin{aligned}\pi_{1+2} = p_1 D_1 + p_2 D_2 + b(x_1^{sh} + x_2^{sh}) + \phi b(x_1^{mh} + x_2^{mh}) - \frac{1}{2}(q_1^2 + q_2^2) \\ + b(1-\phi)(x_{21} - x_{12})\end{aligned} \tag{3.33}$$

Which yields the following first order conditions[45]

$$\begin{aligned}\frac{\partial \pi_{1+2}}{\partial p_1} &= D_1 + p_1 \frac{\partial D_1}{\partial p_1} + b\frac{\partial x_2^{sh}}{\partial p_1} + \phi b\left(\frac{\partial x_1^{mh}}{\partial p_1} + \frac{\partial x_2^{mh}}{\partial p_1}\right) + b(1-\phi)\frac{\partial(x_{21} - x_{12})}{\partial p_1} = 0 \\ \frac{\partial \pi_{1+2}}{\partial q_1} &= p_1 \frac{\partial D_1}{\partial q_1} + b\frac{\partial x_2^{sh}}{\partial q_1} + \phi b\left(\frac{\partial x_1^{mh}}{\partial q_1} + \frac{\partial x_2^{mh}}{\partial q_1}\right) - q_1 + b(1-\phi)\frac{\partial(x_{21} - x_{12})}{\partial q_1} = 0\end{aligned} \tag{3.34}$$

[44]Calculations can be found in appendix A1.2.
[45]Which yields the same SOC's as in (3.24), which we have seen are satisfied for $t > 0$ and $\gamma > 0$.

This gives us the following best response functions[46]

$$p_i(q_i) = \frac{1}{2}\left[\gamma v(1+q_i) - \phi b\right] \tag{3.35}$$

$$q_i(p_i) = \frac{2v}{t}\left[p_i + \phi b\right] \tag{3.36}$$

We recognise these as the same best response functions as in (3.26) and (3.27). In turn this will yield the same equilibrium consumer prices, qualities and total demand as in (3.28)-(3.30). This confirms our expectations of the merged platforms not having incentives to change prices offered to the consumers, nor qualities provided. The explanation can be seen directly from (3.34). A slight increase in consumer price charged by platform 1 will lead to a loss of multi-homing consumers on the left side of the market (equal to $-\phi b$), an increase of single-homing consumers for platform 2 (equal to $+b$) but then also a loss of shared consumers between platform 1 and 2 (equal to $-b(1-\phi)$). In total these effects cancel each other out, and we can then state the following.[47]

Proposition 6 (Multi-homing). *In this media market with multi-homing consumers, a merger leads to*

(i) the same consumer prices and qualities offered by both the merged platforms and the outside platform

(ii) the merged platforms charging a higher price to advertisers for the shared consumers between them

The merger effects found in our multi-homing model are similar to the ones in Anderson et al. (2019). The additional effect found in our model is that the strategic independence of qualities reinforces the competition flipping to the other side of the market, leaving the consumers unaffected by a merger.

[46] See calculations in appendix A1.2.

[47] The effects would be equal for a slight increase in quality.

4 Welfare Analysis

In this section we will look at the economic welfare implications of a merger in our model. For the basis of comparison we will set the number of platforms in the market to $n = 3$, as this is the number of platforms used in the case of a merger in both versions. We compare the welfare expressions for before and after merger, to see how a merger affects the total welfare in the market.[48] We use the following expression $\Delta W = \Delta CS + \Delta AS + \Delta PS$.

4.1 Single-Homing

4.1.1 Consumer Surplus

The consumer surplus per consumer under single-homing is found by inserting the equilibrium consumer prices and qualities into (3.1), before summing across all consumers. The total consumer surplus (CS^{sh}) is given by

$$\begin{aligned} CS_b^{sh} &= 3\left(\int_0^{\frac{1}{6}} (v + vq^{sh} - p^{sh} - ts)ds + \int_0^{\frac{1}{6}} (v + vq^{sh} - p^{sh} - ts)ds\right) \\ &= v + \frac{1}{3}v^2 - \frac{5}{12}t + b \end{aligned} \tag{4.1}$$

$$\begin{aligned} CS_m^{sh} &= 2\left(\int_0^{x_m^m} (v + vq_m^{sh} - p_m^{sh} - ts)ds + \int_0^{x_m^o} (v + vq_m^{sh} - p_m^{sh} - ts)ds\right) \\ &\quad + \left(\int_0^{x_o^m} (v + vq_o^{sh} - p_o^{sh} - ts)ds + \int_0^{x_o^m} (v + vq_o^{sh} - p_o^{sh} - ts)ds\right) \\ &= \frac{108v^6 + 324v^5 + v^4(324b - 639t) - 1296tv^3}{324(2t - v^2)^2} \\ &\quad + \frac{v^2(1236t^2 - 1296bt) + 1296t^2v + 1296bt^2 - 772t^3}{324(2t - v^2)^2} \end{aligned} \tag{4.2}$$

CS_b^{sh} denotes consumer surplus before merger under single-homing, while CS_m^{sh} denotes consumer surplus after merger.[49]

[48] Which is the welfare expression stated in the literature and theory section of this thesis.

[49] See appendix A2 for detailed calculations of the consumer surplus before and after merger.

This yields the following change in consumer surplus under single-homing

$$\Delta CS^{sh} = CS_m^{sh} - CS_b^{sh} = \frac{2t[33tv^2 - 9v^4 - 29t^2]}{81(2t - v^2)^2} \quad < 0 \tag{4.3}$$

This expression is negative for $t > \frac{3}{4}v^2$ (see proof in the appendix A2), which is what we imposed in our single-homing model for a merger to be profitable.

The consumers face higher prices due to both the merged platforms and the outside platform increasing their consumer prices, which has a negative effect on the consumers' utility. As the outside platform increase their quality while the merged platform decrease theirs, more consumers buy from the outside platform, resulting in an increased average quality provision.[50] This means the average consumer in the market experience higher quality. However, a consequence of more consumers purchasing from the outside platform is an increased average transportation cost. This is because more consumers now have to purchase from a platform that is further away from their preferences. In our analysis, the positive effect of more consumers enjoying higher quality is outweighed by the negative effects of an increase in consumer prices and average transportation cost.

4.1.2 Advertiser Surplus

The advertiser surplus under single-homing (AS^{sh}) is calculated by subtracting the advertising price from the advertiser's willingness to pay for placing the ad, and summing across all ads. In our model, for simplicity, we have made the assumption that the demand for ads is perfectly elastic, with a mass $A \equiv 1$. As the platforms completely control the access to their consumers under single-homing, they extract all the value, leaving the advertiser with no surplus. The price advertisers pay for placing ads (b) is equal to their willingness to pay for the attention of the consumers. This is the case both before and after a merger, and so the change in advertiser surplus is

$$\Delta AS^{sh} = AS_b^{sh} = AS_m^{sh} = 0 \tag{4.4}$$

[50]See (3.18) for calculations of the increased average quality provision.

4.1.3 Platform Surplus

The platform surplus under single-homing (PS^{sh}) is calculated by adding together the equilibrium profits of all the platforms in the market. The platform surplus before and after a merger is respectively

$$PS_b^{sh} = 3\pi^{sh}$$
$$PS_m^{sh} = 2\pi_m^{sh} + \pi_o^{sh}$$

Furthermore, the change in platform surplus under single-homing is

$$\Delta PS^{sh} = PS_m^{sh} - PS_b^{sh} = \frac{t\,[9v^2(2v^2 - 7t) + 56t^2]}{81(2t - v^2)^2} \quad > 0 \tag{4.5}$$

The change in platform surplus can be explained by the following. Firstly, the platforms experience a higher profit margin from higher consumer prices. Secondly, the average quality provided in the market is increased after a merger (from (3.18)), resulting in an increased total cost of quality provision. However, similar to Brekke et al. (2017), we find that cost per unit of average quality provided in the market ($\frac{\sum_{i=1}^{n} \frac{1}{2}(q_i)^2}{\bar{q}}$) is equivalent before and after merger.[51] As the average quality provided in the market is higher after merger, it implies that a merger shifts down the upward sloping average cost curve, resulting in a more cost-efficient quality provision after merger (Brekke et al., 2017).

4.1.4 Total Welfare

Using (4.3)-(4.5), we find that the total change in welfare as a result of a merger in this media market with single-homing consumers is

$$\Delta W^{sh} = \Delta CS^{sh} + \Delta AS^{sh} + \Delta PS^{sh} = \frac{t^2[3v^2 - 2t]}{81(2t - v^2)^2} \tag{4.6}$$

We can see that the expression is positive for $t < \frac{3}{2}v^2$, and negative otherwise.

As $t > \frac{3}{4}v^2$ for a merger to be profitable, we have

[51]From (3.18), (3.14), (3.15) and (3.9) we have $\frac{3(\frac{1}{2})(q^{sh})^2}{\bar{q}^{sh}_{before}} = \frac{2(\frac{1}{2})(q_m^{sh})^2 + (\frac{1}{2})(q_o^{sh})^2}{\bar{q}^{sh}_{after}} = \frac{v}{2}$

$$\Delta W^{sh} = \begin{cases} > 0 \; if \quad \frac{3}{4}v^2 < t < \frac{3}{2}v^2 \\ < 0 \; if \quad t > \frac{3}{2}v^2 \end{cases} \tag{4.7}$$

Interestingly, we obtain quite similar results from our welfare analysis under single-homing as Brekke et al. (2017). Despite of the two-sided nature of our model and not including quality cost that depends on demand, we likewise find that *a merger might improve social welfare*. The intuition behind our result is as follows. As in Brekke et al. (2017), the social welfare in this media market depends on a trade-off between the average consumer's benefit of quality, the transportation cost and the cost of quality provision.

The more cost-efficient quality provision can lead to an improved social welfare if the demand responsiveness to quality is sufficiently high. Specifically, if the marginal utility of quality (v) is high, an increase in quality will lead to more consumers choosing the platform with higher quality. In our case, the outside platform is the one with higher quality after merger. Then if v is high, it will increase the share of consumers in the market that will switch from buying access to one of the merged platforms to purchasing access to the outside platform. Then if the consumers perceive the online newspapers as close substitutes (t is low), their disutility of switching from one of the merged platforms to buying from the outside platform is low. In contrast, if the consumers do not perceive the online newspapers as close substitutes (t is high), their disutility of switching from one of the merged platforms to buying from the outside platform will be high. In terms of the Salop circle, a low (high) transportation cost parameter means less (more) decreased utility for the consumers from purchasing access to a platform that is further away from their position on the circle. In combination, if the marginal utility of quality (v) is high relative to t (the demand responsiveness to quality is high), a merger will lead to a large share of the consumers in the market enjoying a higher quality from switching to the outside platform, and facing a low disutility from switching platforms.

Hence, if demand responsiveness to quality is sufficiently high, the negative change in consumer surplus can be outweighed by the positive change in platform surplus, resulting in an improved social welfare after a merger. We then have the following

Proposition 7 (Welfare, Single-homing)**.** *In this media market with exclusively single-homing consumers, a merger leads to*

(i) higher welfare if demand responsiveness to quality is high ($t \in \left\langle \frac{3}{4}v^2, \frac{3}{2}v^2 \right\rangle$)

(ii) lower welfare if demand responsiveness to quality is low ($t \in \left\langle \frac{3}{2}v^2, \rightarrow \right\rangle$)

4.2 Multi-Homing

4.2.1 Consumer Surplus

To find the total consumer surplus under multi-homing (CS^{mh}), we need to specify the consumer surplus accrued from both the most preferred purchase and the extra surplus from the second-most preferred purchase. To find the average transportation cost, we know that the most preferred purchase is located closest to the consumer, while the second-most preferred is the second closest. For the closest purchase, the average distance travelled will be $\frac{1}{4n}$, which with our linear transportation cost and $n = 3$ leads to the average disutility of $\frac{t}{12}$. While for the second-closest purchase, the indifferent consumer (to purchasing the second access) needs to travel at most $\frac{D^{mh}}{2}$ and at least $\frac{1}{2n}$, which means that the average distance traveled is $\frac{1}{2}\left(\frac{1}{2n} + \frac{D^{mh}}{2}\right)$. Then with linear transportation cost and $n = 3$, the average disutility in regards to transportation for the second purchase is $\frac{t}{2}\left[\frac{1}{6} + \frac{D^{mh}}{2}\right]$. While the market is covered by most-preferred products, the number of multi-homing consumers is $\frac{3}{2}[2(D^{mh} - \frac{1}{3})]$. The total consumer surplus is then

$$\begin{aligned} CS_b^{mh} = CS_m^{mh} = &\left[v + vq^{mh} - p^{mh} - \frac{t}{12}\right] \\ &+ \left[(3D^{mh} - 1)\left(\gamma\left(v + vq^{mh} - \frac{t}{2}\left[\frac{1}{6} + \frac{D^{mh}}{2}\right]\right) - p^{mh}\right)\right] \end{aligned}$$

The first bracket is consumer surplus accrued from the first purchase from their most preferred platform, while the second bracket is the extra surplus accrued from the second-most preferred purchase. As we found in our model, the platforms have no incentive to change consumer prices or qualities after a merger, so we are left with the same calculations of the consumer surplus after a merger. Hence, the consumer surplus is unaffected by a merger under multi-homing.

$$\Delta CS^{mh} = CS_m^{mh} - CS_b^{mh} = 0 \tag{4.8}$$

4.2.2 Advertiser Surplus

For advertiser surplus under multi-homing (AS^{mh}), we split the surplus into the one accrued from single-homing consumers and the one from multi-homing consumers. The advertiser surplus for the single-homing consumers is equal to zero, as the platforms extracts all the value. It is when consumers multi-home the advertiser surplus is earned. The multi-homing consumers are worth $b(1+\phi)$ to advertisers, b the first time they are reach, and ϕb the second time they are reached. The advertisers only pay $2\phi b$ per multi-homing consumer (ϕb per platform providing access to that consumer). Hence, the advertiser revenue per multi-homing consumer is $b(1-\phi)$. The total amount of multi-homing consumers is $\frac{3}{2}[2(D^{mh} - \frac{1}{3})]$. But in the case of a merger, the merged platforms gain full control over the access of the shared consumer between them. Thus, they extract all the value by charging the advertisers $b(1+\phi)$ for these shared consumers. The advertiser surplus before and after a merger when there are multi-homing consumers is then

$$AS_b^{mh} = b(1-\phi)\ 3\ \left[D^{mh} - \frac{1}{3}\right]$$
$$AS_m^{mh} = b(1-\phi)\ 2\ \left[D^{mh} - \frac{1}{3}\right]$$

Which leads to the following change in advertiser surplus as a result of a merger

$$\Delta AS = AS_m^{mh} - AS_b^{mh} = \quad -b(1-\phi)\left[\frac{\gamma v + \phi b}{\gamma(t-\gamma v^2)} - \frac{1}{3}\right] < 0 \tag{4.9}$$

The change in advertiser surplus is negative for $t > \gamma v^2$ (see proof in the appendix A2), which we have imposed in our multi-homing model. Notice that the change in advertiser surplus is equal to zero if $\phi = 1$, as the multi-homing consumers is worth the same as the single-homing consumers, leading to the same result as the analysis of the single-homing model. Another extreme case is if there are no multi-homing consumers in the market, which will also lead to the same result as the analysis of the single-homing model.[52]

4.2.3 Platform Surplus

The platform surplus under multi-homing (PS^{mh}) is calculated by adding together the equilibrium profits of all the platforms in the market. The platform surplus before and after a merger when there are multi-homing consumers is

$$
\begin{aligned}
PS_b^{mh} &= 3\pi^{mh} \\
PS_m^{mh} &= 3\pi^{mh} + b(1-\phi)\left(\frac{1}{t}\left[v(2+q_1^{mh}+q_2^{mh}) - \frac{p_1^{mh}+p_2^{mh}}{\gamma}\right] - \frac{1}{3}\right)
\end{aligned}
$$

The second term in the platform surplus after the merger is the additional profits of the merged platforms. This is equal to the extra advertiser profit the merged platforms gain from the shared consumers between them. The change in platform surplus is then

$$
\Delta PS^{mh} = PS_m^{mh} - PS_b^{mh} = b(1-\phi)\left[\frac{\gamma v + \phi b}{\gamma(t-\gamma v^2)} - \frac{1}{3}\right] > 0 \qquad (4.10)
$$

which is positive for $t > \gamma v^2$ (see appendix A2 for proof). Comparing this to the platform surplus change under single-homing, the platforms are able to extract surplus from a merger regardless of whether there are only single-homing consumers or partial multi-homing. This is due to the two-sidedness of the market, where the platform charge higher prices to one side dependent on whether there are multi-homing consumers in the market. Note, that the change in platform surplus will be equal to zero if $\phi = 1$. In that case, the advertisers value the multi-homing consumers the same as single-homing consumers, leaving the platforms with no extra value to extract after a merger. As with the change in advertiser surplus under multi-homing, we will end up with the same result as the analysis of the single-homing model when there are no multi-homing consumers in the market.

[52] Note that, as we stated in our model, we expect there to be partial multi-homing for this version of the model.

4.2.4 Total Welfare

Using (4.8)-(4.10), yields the following total change in welfare as a result of a merger in this media market with multi-homing consumers

$$\Delta W^{mh} = \Delta CS^{mh} + \Delta AS^{mh} + \Delta PS^{mh} = 0 \tag{4.11}$$

The merger enables the merged platforms to extract the entire surplus of the advertisers for their shared multi-homing consumers. However, this additional surplus for the platforms is equivalent to the lost surplus of the advertisers, leaving us with the following result.

Proposition 8 (Welfare, Multi-homing)**.** *In this media market with partially multi-homing consumers, a merger leads to unaffected total welfare (*$\Delta W^{mh} = 0$*)*

Comparing the welfare implications of a merger in the market with only single-homing consumers to partially multi-homing consumers we find that

Proposition 9 (Welfare)**.** *In this media market, a merger leads to decreased surplus for*

(i) consumers when there are solely single-homing consumers

(ii) advertisers when there are partially multi-homing consumers

5 Discussion

In our thesis we want to contribute in closing the gap in the existing literature on welfare implications from a merger in the market of paid digital newspapers. More specifically, we want to illustrate the significance of accounting for multi-homing consumers and quality decisions when analysing the welfare in this market. In this section, we begin by discussing the results of the analysis from the two versions of our model. We will proceed to present possible limitations of our model and provide extensions for further research that may enhance our analysis.

5.1 Findings

With only single-homing consumers in the market, our analysis predicts a merger can potentially lead to improved social welfare if the demand responsiveness to quality is sufficiently high. Hence, the possibility for increased total welfare would not be possible if we only accounted for pricing decisions (and not quality) in our model. As in Brekke et al. (2017), we find that social welfare depends on a trade-off between consumer benefits of quality, the transportation cost and the cost of quality provision. This result indicates that the welfare implications of a merger with only single-homing consumers depend on the consumers perception of the merging digital newspapers. Nevertheless, the consumer surplus is decreased.

Yet we have seen in the analysis of the second version of our model that when we account for multi-homing consumers in this market, it yields quite different results. With multi-homing consumers in the market, the consumer prices and qualities are not affected by a merger. This is due to the strategic independence between the digital newspapers on the consumer side of the market, leaving the consumer welfare unchanged after a merger. Rather, the competition flips to the other side of the market leaving the advertisers with less surplus. This interesting result is in accordance with the findings of Anderson et al. (2019). Howbeit, their analysis is focused on pricing decisions and merger incentives rather than welfare implications of a merger. Our analysis predicts, when there are multi-homing consumers, that a merger will lead to no change in total welfare. This is because the consumers are left unaffected, and the loss in advertiser surplus is equal to the gain in platform surplus.

The ambiguous results of our welfare analysis have illustrated how quality decisions and the possibility for multi-homing consumers can be crucial for the results when analysing merger implications in this media market. Many competition authorities use consumer welfare as a standard in such analysis.[53] When they analyse a merger, the weight is put in favor of the consumers, suggesting that a merger should benefit the consumers. In light of this, our analysis of merger implications on consumer welfare is quite interesting as it emphasises that the outcome may profoundly depend on the assumption of the consumers' purchasing behavior. Specifically, if all consumers buy access to only one digital newspaper, our analysis predicts a merger leads to decreased consumer welfare, yet the degree of decreased consumer welfare is heavily impacted by the demand responsiveness to quality. That is, how much the consumers value an increase in quality relative to how close substitutes the digital newspapers are in the eyes of the consumers. Contrarily, when some consumers buy access to more than one digital newspaper, our analysis suggest a merger leads to unaffected consumer welfare. Altogether, our analysis suggest that quality decisions together with price competition can lead to less decreased welfare for the consumers under single-homing, while multi-homing even leads to unaffected consumer welfare.

A consequence of the impact of demand responsiveness to quality on consumer welfare, is that it yields far more complex results for the merger implications on the society as a whole. Our analysis even predicts that if all consumers buy access to only one digital newspaper, a merger can lead to improved social welfare, if the consumers' marginal value of quality is sufficiently high relative to them perceiving the digital newspapers as close substitutes. If not, the social welfare will be decreased. However, if some of the consumers in the market choose to multi-home, the total welfare will be completely unaffected. This is because the consumers are left unaffected and the lost surplus of the advertisers is fully extracted by the platforms.

[53]Examples of competition authorities that use consumer welfare as a standard is the US, the EU and Norway.

5.1.1 Robustness Check

In our model the price and quality decisions are made simultaneously and not sequentially, as we believe it is the most realistic assumption for this media market. However, if the timing was sequential, the digital newspapers would have to commit to a fixed level of quality in the first stage, and this decision would have to be observed by the rivals, before they choose their consumer prices in the second stage. We have calculated the equilibrium outcomes from sequential timing in appendix A3. For our single-homing model, we find some differing results with sequential timing which we further discuss below. For the multi-homing model, on the other hand, we find the same results for sequential timing as in our model with simultaneous timing. Hence, it yields the same welfare analysis as in section 4.2.

Sequential timing would yield only quantitatively different equilibrium results, but some different qualitative results when comparing pre- and post-merger equilibria *for the single-homing model*. There is an interval for t where a merger would lead to the merged platforms charging lower consumer prices post-merger. Comparing to our model with simultaneous timing, where we found that the merged platforms will increase their consumer prices regardless. This in turn leads to different results of the welfare analysis. The change in consumer surplus will for a small interval of t actually be positive, in contrast to the simultaneous model where it is always negative.[54] For the change in advertiser surplus, we have the same reasoning as in the simultaneous model, in which the the platforms extract all the value leading to zero surplus for the advertiser before and after merger. The change in platform surplus is as predicted always positive. Summarising we find that the change in total welfare is strictly negative, which is in contrast to our simultaneous model and the results of Brekke et al. (2017), where the social welfare might actually be improved as a result of a merger.[55]

In light of the qualitatively dissimilar results of the welfare analysis for sequential timing, and as we cannot be certain which timing is the correct assumption for this media market, it suggests that our results from the single-homing model may not be very robust. We are presumably the first to analyse the welfare change of a merger with sequential

[54]See calculations of consumer surplus with sequential timing in A3.
[55]Remember that for our simultaneous model the change in welfare is positive for a interval of t.

timing in this setting.

5.2 Extensions

We have shown that the implications of a merger on welfare in this market from the digital newspapers' choice of consumer prices and qualities are substantially different depending on whether there are multi-homing consumers in the market. However, relaxing some of the underlying assumptions of our model can have implications for the results of our analysis. Our model is rather simple, but it is meant to highlight effects of including multi-homing consumers and quality decisions when analysing the welfare implications of a merger. Hence, the goal is not to capture all the aspects of such a complex market but to unveil economic intuition.

5.2.1 Advertiser Demand

The advertiser demand was deliberately set to be perfectly elastic, meaning the platforms do not compete on the advertiser side of the market. This was to simplify our model, but a more realistic representation would be a downward-sloping demand curve, where the advertisers willingness to pay decrease with the advertiser price. Anderson et al. (2019) simplifies the advertiser demand in the same way and argue that their results hold with a more general advertiser demand. However, for our analysis with quality decisions, this argument may no longer hold. If the advertiser demand were to be dependent on the quality provided by the platforms, it might have implications for the strategic interactions in both versions of our model. Specifically for our model, as the readers demand is affected by quality it would in turn affect the demand of the advertisers. Moreover, advertisers might be concerned with their own reputation, and in example wanting to only be associated with high quality digital newspapers. This makes it particularly interesting for the result of strategic independence under multi-homing. Specifically, to analyse the implications it might have on the welfare of the consumers and the society as a whole if the strategic independence between the competing digital newspapers were to be replaced by strategic interaction. This would make the analysis a lot more comprehensive, and we believe our thesis serves as a good starting-point for further research.

5.2.2 Attitudes Toward Advertisement

Furthermore, we have assumed that the readers are ad-neutral, that is, not positively or negatively affected by the amount of advertisement placed on the digital newspapers. This is because we focus on a media market where we do not expect there to be strong effects of advertisement (Anderson et al., 2019). From the empirical research done on the topic of attitudes toward advertisement, there is no clear answer as to what is the most realistic assumption for the media market. Research done by Kaiser and Song (2009) and Depken and Wilson (2004) on printed media suggest that advertisement can be perceived as both good and bad, while Wilbur (2008) found that increasing advertisement in the television market led to a significant decrease in audience size and that viewers tend to be averse to advertising. Whether the readers like or dislike advertisement may both have implications for the results of our analysis. In order for the digital newspapers to internalise the network externalities between the two sides of the market, it will further require that the model has an advertiser demand that is not perfectly elastic.

If the readers were to be ad-loving, there would exist a positive externality between the readers and the advertisers. This is typical for other types of two-sided markets, in example credit-cards, where both sides clearly benefit from an increase in the amount of participants on the other side. On the other hand, if the readers were to dislike advertisement there would exist negative externalities one way. Raising the ad-levels (decrease ad price) would have a negative impact on the demand of readers. If the demand of the advertiser were to be dependent on the quality provided by the platforms in addition to consumers having an attitude towards advertisement, the strategic interaction in both versions of our model would be more complex. This makes it an intriguing area for further research. However, incorporating this could compromise the economic intuition of the model and make the algebra less elegant, and as discussed, there is no clear-cut answer as to what is the most realistic assumption for this media market.

5.2.3 Merger Conditions

When a merger occurs in our model, it entails cooperation on the pricing and quality decisions, leaving the number of digital newspapers in the market unchanged. Contrarily, a merger could involve closing down one of the merged platforms, reducing the number of digital newspapers in the market. This would be a profitable strategy if it allows them to reduce cost. Brekke et al. (2017) argues that in a market with single-homing consumers, this will lead to higher consumer prices and qualities by *all* firms. The increase in demand for both products, result in higher equilibrium consumer prices, which in turn would lead to higher quality levels.[56] From the strategic independence of consumers prices and qualities when there are multi-homing consumers, such a merger assumption would presumably not change the results of the second version of our model.

5.2.4 Quality Specifications

In our model, we have made assumptions about the consumers' preferences in terms of the quality a platform provides. We have assumed that an increase in quality has the same effect on utility among all consumers. However, in accordance with Anderson et al. (2017), we believe it would be interesting to analyse quality in terms of functionality for this media market. Specifically, the utility of the consumer would then be increasing in the number of functionalities of the paid digital newspaper and the marginal value of increasing functionalities would be increasing the more horizontally differentiated the consumers are. For our multi-homing model, we implicitly say that an increase in quality provided by both platforms will lead to an increase in the incremental value for the second purchase regardless of what this quality entails. In terms of functionality, however, there would probably be overlapping functionalities of the two digital newspapers the consumers decide to multi-home, and it is reasonable to believe that this might affect how consumers value buying access to both. This could in turn affect the likelihood of multi-homing consumers, which can have further implications for the price and functionality decisions of the digital newspapers and the welfare in this media market.

We experimented with this way of modelling quality in the market of paid digital newspapers by implementing the functionality formulation from Anderson et al. (2017) in our model. We have provided calculations and in-depth explanations of our attempts in appendix A4. For our single-homing model, we were not able to find a symmetric equilibrium using functionality as a way of modelling quality for either simultaneous or

[56] From the positive effect own consumer price has on the best response function for quality.

sequential timing. For our multi-homing model, our first attempt was to implement the same way of modelling the incremental value as in Anderson et al. (2017), but we were not able to find a symmetric equilibrium for either simultaneous or sequential timing. However, by somewhat simplifying the formulation for incremental value from Anderson et al. (2017), we were able to find a symmetric equilibrium with sequential timing.

Even though we were able to find a symmetric equilibrium consumer price and functionality with the simplified formulation for our multi-homing model, we decided to not pursue this way of modelling quality in our thesis.[57] Firstly, we believe sequential choice of functionality and price is not a very realistic assumption for this media market. Secondly, the expressions are not very attractive and do not yield a lot of economic intuition. Thirdly, it did not have the dynamic feature for overlapping functionalities, which was a particularly interesting feature of the functionality formulation for multi-homing from Anderson et al. (2017). Fourthly, we were not able to find a sufficient way of modelling functionality in our single-homing model, so we would not have results from single-homing to compare to the multi-homing results.[58] Lastly, even though functionality is an interesting way of modelling quality for this media market, we believe it is not the only realistic representation of quality in this market. In total, this is why we disregarded going further with this way of formulating quality but we hope our attempts at modelling functionality sparks the interest for further research on the topic.

Furthermore, our assumption for better journalism or digital features might lead to spillover effects from quality investments. More specifically, if one of the newspapers were to invest and implement a better way of writing their articles (better journalism), the rivals might implement the same way of writing without having to invest in quality. Moreover, if they were to invest in research on new digital features which turns out to be valuable in the eyes of the consumer, the rivals may feel inspired to implement the same type of digital features leading to saved cost for the rival. It would be interesting to see whether the results of this analysis might differ if one were to account for such spillover effects.

[57] We did not investigate whether the second order condition holds for this equilibrium.
[58] Comparing single-homing to multi-homing is a crucial part of the purpose of our thesis.

5.2.5 Location Analysis

In our model we have assumed that the platforms are located symmetrically around the Salop circle, indicating that the paid digital newspapers represent preference extremes. As we analyse merger implications and not location in such a market, we have not conducted any in-depth location analysis. Nevertheless, we will briefly discuss the possible incentives to change locations in both our models, considering we use a Salop framework with linear transportation cost.[59]

For single-homing, if platform 1 moves a small step towards platform 3, it looses one consumer on the right side and gains one on the left side, hence there is no change in demand of platform 1. The location change of platform 1 will decrease the demand of platform 3 and increase the demand of platform 2. Their opposite responds for consumer price and quality to the change in their demand will in combination not affect the demand of platform 1, leaving the profit of platform 1 unchanged. Hence, the platforms are indifferent to moving locally. If platform 1 and 2 merge, the incentives to change locations will depend on the effects that arise from the two-sidedness of this media market. If both of the merged platforms move a small step closer to platform 3, it will increase their demand, but also make them less differentiated to platform 3, hence intensifying the competition. The incentives to change location will then depend on whether the gain from the advertiser side of the market exceeds the possible loss on the consumer side from increased competition.

Similar to the case of only single-homing consumers, the platforms are locally indifferent to moving under multi-homing. If we again consider platform 1 moving a small step toward platform 3, it will loose a multi-homing consumer on the right side and gain one on the left. Platform 1's profit is left unchanged, both from the consumer side and the advertiser side. In addition the location change leaves the total demand of both rivals unchanged, hence giving them no incentives to change either consumer price or quality. This is in accordance with Anderson et al. (2019) who further specified that any set of locations where there are multi-homing consumers on each side of the firms constitutes an

[59]The assumption of firms located equidistantly in a circular city has only been justified for quadratic transportation cost (Tirole, 1988).

equilibrium. Each pair of such locations must then be more than D apart and less than $2D$ apart. Furthermore, when platform 1 and 2 merge, neither one of them have a strict incentive to change location locally. Suppose both move a step closer to platform 3. The merged platforms will then gain a multi-homing consumer in the direction they compete with platform 3, gaining $2\phi b$. But this will also turn two multi-homing consumers that they share between them into single-homing consumers, hence, losing $2\phi b$.[60] The merged platforms profits are thus left unaffected if they change their location.

[60] From $2b(1+\phi) - 2b = 2\phi b$.

6 Conclusion

The main purpose of this thesis is to examine how the strategic interaction between the competing digital newspapers differs when some of the consumers in the market multi-home. More specifically, how multi-homing impacts the merger implications on welfare in this media market. We believe it is important to consider quality investments and the possibility of multi-homing consumers to better understand the implications of a merger in such a complex market.

To uncover the implications of a merger, we have developed two version of a theoretical model. The first version of our model is with solely single-homing consumers, while the second version allows for multi-homing consumers. We use Salop's circular city as a basis in order to avoid a monopoly situation after merger. Even with the two-sided nature of our model, we obtain similar results as in previous literature for the strategic interaction under single-homing, when the competing digital newspapers simultaneously set their consumer prices and qualities. However, we strikingly find that strategic interaction between the competing digital newspapers for both qualities and consumer prices is replaced by strategic independence under multi-homing.

When consumers solely single-home, our model predicts that a merger leads to all digital newspapers increasing their consumer price, which is in line with traditional literature. Howbeit, the choice for qualities are not uniform. For the merged digital newspapers, the weaker quality effect on demand as well as the unaffected cost of quality leads to a lower quality provided. The response from the non-merged digital newspaper will be to increase their quality, as a reduction of rival's quality induces a higher consumer price, which in turn makes it optimal to increase quality to obtain higher demand.

Meanwhile, the interaction between the competing digital newspapers drastically change when some consumers decide to multi-home. A lower consumer price by one of the digital newspaper will not compel the previously single-homing consumer to substitute the competing digital newspaper, but rather induce them to buy access to both. Then only the ratio of single-homing and multi-homing consumers of the competing digital newspaper is affected, leaving its total demand unchanged. The profit of the competing digital newspaper will then be lower from selling more of the less valuable "eyeballs" to the advertisers. However, its unchanged total demand and inability to affect its number of single-homing consumers, leaves it with no incentive to change its consumer price or quality. This leads to strategic independence on the consumer side of the market, and so the consequences of a merger under multi-homing compared to single-homing are striking. Multi-homing flips the competition completely to the other side of the market: the merged newspapers will charge higher prices to the advertisers they share between them and charge the same consumer prices and qualities.

To fully assess the implications of the merger results from our model, we analyse the welfare change from both versions. Our main contribution is finding that implications of a merger when consumers buy access to two digital newspapers greatly differs from when they buy access to only one. We find that a merger can even be welfare enhancing under single-homing, while welfare is in fact unaffected under multi-homing. Even though consumers are strictly worse off from a merger under single-homing, they will be less worse off if the demand responsiveness to quality is sufficiently high, leading to a positive change in the total welfare. This implication would not be uncovered if we did not consider quality decisions for this media market. Interestingly, when some of the consumers in the market decide to multi-home, the strategic independence for consumer prices and qualities leads to consumers being unaffected by a merger. As multi-homing results in the competition flipping to the other side of the market, it is rather the advertisers who bear the burden of a merger. Still, the decrease in surplus of the advertisers is cancelled out by the extracted surplus of the digital newspapers, leaving the total welfare unchanged under multi-homing.

Our research show how including quality decisions and the possibility for multi-homing consumers can generate significantly ambiguous results when analysing merger implications in this media market. As we have discussed, there are many possible extensions for research, and we hope we have sparked interest for the topic of merger implications under multi-homing with our thesis.

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Appendices

Appendix A1 refers to our model in this thesis, while appendix A2 refers to our analysis. Appendix A3 presents (parts of) the model with sequential timing. Lastly, appendix A4 contains results from our attempts at various approaches to formulate quality in our model.

A1 Main Model

A1.1 Single-Homing

Calculation of symmetric equilibrium profit

From (3.9) we have the following symmetric equilibrium consumer price and quality:

$$\begin{aligned} p^{sh} &= \frac{t}{n} - b \\ q^{sh} &= \frac{v}{n} \end{aligned}$$

Using these in (3.3) together with the equilibrium demand ($D^{sh} = \frac{1}{n}$) yields the following symmetric equilibrium profit from (3.9)

$$\begin{aligned} \pi^{sh} &= \left(\frac{t}{n} - b + b\right)\frac{1}{n} - \frac{1}{2}\left(\frac{v}{n}\right)^2 \\ &= \frac{1}{2n^2}(2t - v^2) \end{aligned}$$

Calculations of best response functions after merger

To find the best response function for consumer prices of the merged platforms under single-homing, we use the first order condition from (3.11)

$$\frac{\partial \pi_{1+2}}{\partial p_1} = D_1 + (p_1 + b)\frac{\partial D_1}{\partial p_1} + (p_2 + b)\frac{\partial D_2}{\partial p_1} = 0$$

setting $p_1 = p_2$ and $q_1 = q_2$ yields

$$p_1 = \frac{t}{3} + \frac{v(q_1 - q_3) + p_3 - b}{4}$$

Furthermore, to find the best response function for quality of the merged companies under single-homing, we use the first order condition from (3.11)

$$\frac{\partial \pi_{1+2}}{\partial q_1} = (p_1 + b)\frac{\partial D_1}{\partial q_1} - q_1 + (p_2 + b)\frac{\partial D_2}{\partial q_1} = 0$$

setting $p_1 = p_2$ and $q_1 = q_2$ yields

$$q_1 = \frac{(p_1 + b)v}{2t}$$

Platform 3 (or the outside platform) has the same best response functions as in (3.5) and (3.6):

$$\begin{aligned} p_3 &= \frac{t}{6} + \frac{v(2q_3 - q_1 - q_2) + (p_2 + p_1)}{4} - \frac{b}{2} \\ q_3 &= \frac{v(p_3 + b)}{t} \end{aligned}$$

By setting $p_1 = p_2 = p_m$, $p_3 = p_o$, $q_1 = q_2 = q_m$ and $q_3 = q_o$, it yields the best response functions from (3.12a)-(3.13b):

$$\begin{aligned} p_m &= \frac{t}{3} + \frac{v(q_m - q_o) + p_o - b}{2} \\ q_m &= \frac{(p_m + b)v}{2t} \\ p_o &= \frac{t}{6} + \frac{v(q_o - q_m) + p_m - b}{2} \\ q_o &= \frac{(p_o + b)v}{t} \end{aligned}$$

Calculations of asymmetric equilibrium demands and profits after merger

To find the asymmetric equilibrium demand and profits we use the asymmetric equilibrium consumer prices and qualities from (3.14)-(3.15) in (3.2) and (3.3):

$$D_m^{sh} = \frac{1}{3} + \frac{v\left(\frac{v(5t-3v^2)}{9(2t-v^2)} - \frac{v(8t-3v^2)}{9(2t-v^2)}\right) - \left(\frac{2t(5t-3v^2)}{9(2t-v^2)} - b\right) + \left(\frac{t(8t-3v^2)}{9(2t-v^2)} - b\right)}{2t} \\ = \frac{5t-3v^2}{9(2t-v^2)} \tag{A.1}$$

$$D_o^{sh} = \frac{1}{3} + \frac{v\left(\frac{v(8t-3v^2)}{9(2t-v^2)} - \frac{v(5t-3v^2)}{9(2t-v^2)}\right) - \left(\frac{t(8t-3v^2)}{9(2t-v^2)} - b\right) + \left(\frac{2t(5t-3v^2)}{9(2t-v^2)} - b\right)}{t} \\ = \frac{8t-3v^2}{9(2t-v^2)} \tag{A.2}$$

$$\pi_m^{sh} = \left(\frac{2t(5t-3v^2)}{9(2t-v^2)} - b + b\right)\left(\frac{5t-3v^2}{9(2t-v^2)}\right) - \frac{1}{2}\left(\frac{v(5t-3v^2)}{9(2t-v^2)}\right)^2 \\ = \frac{(5t-3v^2)^2(4t-v^2)}{162(2t-v^2)^2}$$

$$\pi_o^{sh} = \left(\frac{t(8t-3v^2)}{9(2t-v^2)} - b + b\right)\left(\frac{8t-3v^2}{9(2t-v^2)}\right) - \frac{1}{2}\left(\frac{v(8t-3v^2)}{9(2t-v^2)}\right)^2 \\ = \frac{(8t-3v^2)^2}{162(2t-v^2)}$$

Proof that merger is profitable when $t > \frac{3}{4}v^2$

When comparing the joint profits of the two merged platforms before and after merger, we get the difference from (3.16) when subtracting the pre-merger profit from the post-merger profit

$$\frac{t(7t-4v^2)(4t-3v^2)}{81(2t-v^2)^2}$$

The denominator of this expression is strictly positive, so for the total expression to be strictly positive, we need a positive numerator.

$$t(7t-4v^2)(4t-3v^2)$$

As t is strictly positive, and $(4t - 3v^2) < (7t - 4v^2)$, we can isolate t in $(4t - 3v^2)$ and find that $t > \frac{3}{4}v^2$ for the numerator to be strictly positive.

A1.2 Multi-Homing

Consumer utility to platform demand

Calculation of (3.19):

$$\begin{aligned}
&u_{12} = 0\\
&\Rightarrow v(1+q_2)\gamma - \gamma t|x_2 - x_{12}| - p_2 = 0\\
&\Rightarrow x_{12} = x_2 - \frac{1}{t}\left[v(1+q_2) - \frac{p_2}{\gamma}\right]\\
&\Rightarrow x_{12} = \frac{1}{n} - \frac{1}{t}\left[v(1+q_2) - \frac{p_2}{\gamma}\right]
\end{aligned}$$

Calculation of (3.20):

$$\begin{aligned}
&u_{1n} = 0\\
&\Rightarrow v(1+q_n)\gamma - \gamma t|x_{1n} - x_n| - p_n = 0\\
&\Rightarrow x_{1n} = x_n + \frac{1}{t}\left[v(1+q_n) - \frac{p_n}{\gamma}\right]\\
&\Rightarrow x_{1n} = \frac{n-1}{n} + \frac{1}{t}\left[v(1+q_n) - \frac{p_n}{\gamma}\right]
\end{aligned}$$

Calculation of (3.21):

$$\begin{aligned}
x_{12} + (1 - x_{1n}) &= \frac{1}{n} - \frac{1}{t}\left[v(1+q_2) - \frac{p_2}{\gamma}\right] + (1 - (\frac{n-1}{n} + \frac{1}{t}\left[v(1+q_n) - \frac{p_n}{\gamma}\right]))\\
&= \frac{2}{n} - \frac{1}{t}\left[v(2+q_2+q_n) - \frac{p_2+p_n}{\gamma}\right]
\end{aligned}$$

Which gives the number of single-homing consumers on platform i $(\neq j \neq k)$:

$$x_i^{sh} = \frac{2}{n} - \frac{1}{t}\left[v(2+q_j+q_k) - \frac{p_j+p_k}{\gamma}\right]$$

Calculation of (3.22):

$$\begin{aligned}
&u_{21} = 0 \\
&\Rightarrow v(1+q_1)\gamma - \gamma t|x_{21} - x_1| - p_1 = 0 \\
&\Rightarrow x_{21} = x_1 + \frac{1}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right] \\
&\Rightarrow x_{21} = \frac{1}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right]
\end{aligned} \tag{A.3}$$

$$\begin{aligned}
&u_{31} = 0 \\
&\Rightarrow v(1+q_1)\gamma - \gamma t|x_1 - x_{31}| - p_1 = 0 \\
&\Rightarrow x_{31} = x_1 - \frac{1}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right] \\
&\Rightarrow x_{31} = 1 - \frac{1}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right]
\end{aligned} \tag{A.4}$$

Finding total demand for platform 1, which is the distance between x_{31} and x_{21}:

$$\begin{aligned}
D_1 &= x_{21} + (1 - x_{31}) \\
&= \frac{1}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right] + \left(1 - \left(1 - \frac{1}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right]\right)\right) \\
&= \frac{2}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right]
\end{aligned}$$

Which gives the total number of consumers on platform i ($\neq j \neq k$):

$$D_i = \frac{2}{t}\left[v(1+q_i) - \frac{p_i}{\gamma}\right]$$

Calculations of best response functions

Using (3.25), we can derive the best response functions for prices (3.26):

$$\begin{aligned}
\frac{\partial \pi_i}{\partial p_i} &= D_i + p_i \frac{\partial D_i}{\partial p_i} + \phi b \frac{\partial x_i^{mh}}{\partial p_i} = 0 \\
&\Rightarrow p_i(q_i) = \frac{1}{2}\left[\gamma v(1+q_i) - \phi b\right]
\end{aligned}$$

Furthermore, using (3.25), we can derive the best response function for qualities (3.36):

$$\begin{aligned}\frac{\partial \pi_i}{\partial q_i} &= p_i \frac{\partial D_i}{\partial q_i} + \phi b \frac{\partial x_i^{mh}}{\partial q_i} - q_i = 0 \\ &\Rightarrow q_i(p_i) = \frac{2v}{t}\left[p_i + \phi b\right]\end{aligned}$$

Calculations of symmetric equilibrium

We find the symmetric equilibrium total demand from (3.30) by using (3.28) in (3.22):

$$\begin{aligned}D^{mh} &= \frac{2}{t}\left[v(1+q^{mh}) - \frac{p^{mh}}{\gamma}\right] \\ &= \frac{\gamma v + \phi b}{\gamma(t-\gamma v^2)}\end{aligned}$$

We proceed to find the symmetric equilibrium single-homing demand from (3.31) by using (3.28) in (3.21):

$$\begin{aligned}x^{sh} &= \frac{2}{n} - \frac{1}{t}\left[v(2+q^{mh}+q^{mh}) - \frac{(p^{mh}+p^{mh})}{\gamma}\right] \\ &= \frac{2}{n} - \frac{\gamma v + \phi b}{\gamma(t-\gamma v^2)} \\ &= \frac{2}{n} - D^{mh}\end{aligned}$$

Then we find the symmetric equilibrium multi-homing demand from (3.31) by using (3.28) in (3.23):

$$\begin{aligned}x^{mh} &= \frac{1}{t}\left[v(2q^{mh}+q^{mh}+q^{mh}+4) - \frac{(2p^{mh}+p^{mh}+p^{mh})}{\gamma}\right] - \frac{2}{n} \\ &= 2\left[\frac{\gamma v + \phi b}{\gamma(t-\gamma v^2)} - \frac{1}{n}\right] \\ &= 2\left[D^{mh} - \frac{1}{n}\right]\end{aligned}$$

To find the symmetric equilibrium profit in (3.29), we use the symmetric equilibrium consumer price and quality from (3.28) and the equilibrium demands from (3.30) and (3.31) in (3.24):

$$\pi^{mh} = \left(\frac{\phi b\ (2\,\gamma\,v^2 - t) + t\gamma\,v}{2(t-\ \gamma\,v)^2}\right)\left(\frac{\gamma\,v + \phi b}{\gamma\ (t-\gamma\,v^2)}\right) + b\left(\frac{2}{n} - \frac{\gamma\,v+\phi b}{\gamma\ (t-\gamma\,v^2)}\right)$$
$$+\,\phi b\left(2\left(\frac{\gamma\,v+\phi b}{\gamma\ (t-\gamma\,v^2)} - \frac{1}{n}\right)\right) - \frac{1}{2}\left(\frac{v^2\,(\gamma\,v+\phi b)}{(t-\gamma\,v^2)}\right)^2$$
$$= \frac{(n-4\,b+4\,\phi b)\,v^2\gamma^2 + (4\,t\,(b-\phi b) - 2\,v\,(b-2\,\phi b)\,n)\,\gamma - n\phi b\ (2\,b-3\,\phi b)}{2\,n\gamma\ (t-\gamma\,v^2)}$$

Calculations of the number of shared consumers between merged platforms

To find the number of shared consumers between the merged platforms, we subtract (3.19) from (A.3):

$$x_{21} - x_{12} = \frac{1}{t}\left[v(1+q_1) - \frac{p_1}{\gamma}\right] - \left(\frac{1}{n} - \frac{1}{t}\left[v(1+q_2) - \frac{p_2}{\gamma}\right]\right)$$
$$= \frac{1}{t}\left[v(2+q_1+q_2) - \frac{p_1+p_2}{\gamma}\right] - \frac{1}{n}$$

Calculations of reaction functions after merger

Using the first order conditions from (3.34), we can derive the best response functions for consumer prices in (3.35):

$$\frac{\partial \pi_{1+2}}{\partial p_1} = D_1 + p_1\frac{\partial D_1}{\partial p_1} + b\frac{\partial x_2^{sh}}{\partial p_1} + \phi b\left(\frac{\partial x_1^{mh}}{\partial p_1} + \frac{\partial x_2^{mh}}{\partial p_1}\right) + b(1-\phi)\frac{\partial(x_{21}-x_{12})}{\partial p_1} = 0$$
$$\Rightarrow p_i(q_i) = \frac{1}{2}[\gamma v(1+q_i) - \phi b]$$

Furthermore, by using (3.34), we can derive the best response functions for qualities in (3.36):

$$\frac{\partial \pi_{1+2}}{\partial q_1} = p_1\frac{\partial D_1}{\partial q_1} + b\frac{\partial x_2^{sh}}{\partial q_1} + \phi b\left(\frac{\partial x_1^{mh}}{\partial q_1} + \frac{\partial x_2^{mh}}{\partial q_1}\right) - q_1 + b(1-\phi)\frac{\partial(x_{21}-x_{12})}{\partial q_1} = 0$$
$$\Rightarrow q_i(p_i) = \frac{2v}{t}[p_i + \phi b]$$

A2 Welfare Analysis

Calculations of consumer surplus under single-homing

The demand of platform i given by (3.2) can be written as:

$$D_i^{sh} = x_i^j + x_i^k \tag{A.5}$$

x_i^j is the location of the consumer who is indifferent between buying from platform i and platform j and is given by

$$x_i^j = \frac{1}{2n} + \frac{v(q_i - q_j) - p_i + p_j}{2t} \tag{A.6}$$

x_i^k is the location of the consumer who is indifferent between buying from platform i and platform k and is given by

$$x_i^k = \frac{1}{2n} + \frac{v(q_i - q_k) - p_i + p_k}{2t} \tag{A.7}$$

The consumer surplus of the consumers buying from platform i can then be expressed as

$$CS_i = \int_0^{x_i^j} (v + vq_i - p_i - ts)ds + \int_0^{x_i^k} (v + vq_i - p_i - ts)ds \tag{A.8}$$

We can find the total consumer surplus in the market by adding together all the consumer surpluses.

In the symmetric equilibrium the demand of each platform is equal to $\frac{1}{3}$ ($\frac{1}{6}$ on each side of the platform) and the equilibrium consumer price and quality is given by (3.9). Using this in (A.8) and summing across all platforms in the market we have the following total consumer surplus

$$\begin{aligned} CS_b^{sh} &= 3\left(\int_0^{\frac{1}{6}} (v + vq^{sh} - p^{sh} - ts)ds + \int_0^{\frac{1}{6}} (v + vq^{sh} - p^{sh} - ts)ds\right) \\ &= v + \frac{1}{3}v^2 - \frac{5}{12}t + b \end{aligned} \tag{A.9}$$

We proceed to find the consumer surplus in the asymmetric equilibrium after merger. To find the locations of the indifferent consumers, we use the equilibrium consumer prices and qualities from (3.14)-(3.15) in (A.6) and (A.7)

$$\begin{aligned} x_m^m &= \frac{1}{6} \\ x_o^m &= \frac{5t - 3v^2}{18(2t - v^2)} \\ x_m^o &= \frac{8t - 3v^2}{18(2t - v^2)} \end{aligned} \tag{A.10}$$

Using (3.14)-(3.15) and (A.10) in (A.8) and summing across all platforms in the market we have the following total consumer surplus in the asymmetric equilibrium after merger

$$\begin{aligned} CS_m^{sh} &= 2\left(\int_0^{x_m^m} (v + vq_m^{sh} - p_m^{sh} - ts)ds + \int_0^{x_m^o} (v + vq_m^{sh} - p_m^{sh} - ts)ds\right) \\ &+ \left(\int_0^{x_o^m} (v + vq_o^{sh} - p_o^{sh} - ts)ds + \int_0^{x_o^m} (v + vq_o^{sh} - p_o^{sh} - ts)ds\right) \\ &= \frac{108v^6 + 324v^5 + v^4(324b - 639t) - 1296tv^3}{324(2t - v^2)^2} \\ &\quad + \frac{v^2(1236t^2 - 1296bt) + 1296t^2v + 1296bt^2 - 772t^3}{324(2t - v^2)^2} \end{aligned} \tag{A.11}$$

Proof that the change in consumer surplus is negative under single-homing when $t > \frac{3}{4}v^2$

From (4.3) we have that the change in consumer surplus is as follows

$$\Delta CS^{sh} = CS_m^{sh} - CS_b^{sh} = \frac{2t[33tv^2 - 9v^4 - 29t^2]}{81(2t - v^2)^2}$$

The denominator of this expression is always positive. It is the expression within the brackets that determines whether the total expression is negative or positive.

$$[33tv^2 - 9v^4 - 29t^2]$$

Isolation for t yields

$$t = \frac{33 \pm 3\sqrt{5}}{58}v^2$$

The expression is negative for $t < \frac{33-3\sqrt{5}}{58}v^2$ and $t > \frac{33+3\sqrt{5}}{58}v^2$, and positive for $\frac{33-3\sqrt{5}}{58}v^2 < t < \frac{33+3\sqrt{5}}{58}v^2$. Hence, the change in consumer surplus is negative for $t > \frac{3}{4}v^2$.

Proof that the change in advertiser surplus is negative under multi-homing when $t > \gamma v^2$

From (4.9) we have the following change in advertiser surplus

$$\Delta AS = AS_m^{mh} - AS_b^{mh} = \quad -b(1-\phi)\left[\frac{\gamma v + \phi b}{\gamma(t-\gamma v^2)} - \frac{1}{3}\right] < 0$$

The expression outside the bracket is strictly negative as long as $\phi < 1$, and zero otherwise. For the total expression to be negative, the expression inside the bracket must be strictly positive. The expression inside the bracket is positive if the first fraction is positive, which it is when the numerator is positive:

$$\gamma(t-\gamma v^2)$$

This is strictly positive for $t > \gamma v^2$. For the expression inside the bracket to be positive we also need

$$\frac{\gamma v + \phi b}{\gamma(t-\gamma v^2)} > \frac{1}{3}$$

We recognise the fraction as the total demand under multi-homing (D^{mh}). From (3.31) we know that the number of multi-homing consumers is equal to zero when $D^{mh} = \frac{1}{n}$ and the number of single-homing consumers is equal to zero when $D^{mh} = \frac{2}{n}$. For $n = 3$, the expression in the bracket will be either zero or strictly positive.

Proof that the change in platform surplus is positive under multi-homing when $t > \gamma v^2$

From (4.10) we have the following change in platform surplus

$$\Delta PS^{mh} = PS_m^{mh} - PS_b^{mh} = b(1-\phi)\left[\frac{\gamma v + \phi b}{\gamma(t-\gamma v^2)} - \frac{1}{3}\right] > 0$$

The expression outside the bracket is strictly positive long as $\phi < 1$, and zero otherwise. Then the expression inside the bracket must be strictly positive for the total expression to be strictly positive. We recognise this expression as the expression from the proof of advertiser surplus being negative under multi-homing when $t > \gamma v^2$, where we proved that this expression is strictly positive when $t > \gamma v^2$ (see proof for details).

A3 Sequential Model

Single-homing: Calculations of best response functions and equilibrium outcomes

We consider the following two-stage game:

1. Each platform chooses its quality level

2. After observing the rival's choice of quality level, each platform set their consumer price

From the second stage we have the same first order condition for the consumer price decision as when quality and price are chosen simultaneously in (3.4) (from now on referred to as simultaneous timing). This yields the same reaction function as from (3.5).

We then have the following equilibrium consumer price in the second stage

$$p_i^*(q_i, q_j, q_k) = \frac{t}{n} + \frac{v(2q_i - q_j - q_k)}{5} - b \tag{A.12}$$

The advertising price acts as a "negative" marginal cost in this case as well.

In the first stage of the game the platforms commit to a quality level anticipating the consumer prices that will be chosen in the second stage. This yields the following first order condition for the quality decision of firm i

$$\frac{\partial \pi_i}{\partial q_i} = D_i \frac{\partial p_i^*}{\partial q_i} + (p_i^* + b)\left[\frac{\partial D_i}{\partial q_i} + \frac{\partial D_i}{\partial p_i^*}\frac{\mathrm{d}p_i^*}{\mathrm{d}q_i} + \frac{\partial D_i}{\partial p_j^*}\frac{\mathrm{d}p_j^*}{\mathrm{d}q_i} + \frac{\partial D_i}{\partial p_k^*}\frac{\mathrm{d}p_k^*}{\mathrm{d}q_i}\right] = 0 \tag{A.13}$$

Which leads to the following reaction function for quality for firm i

$$q_i(q_j, q_k) = \frac{20vt}{n(25t - 8v^2)} - \frac{4v^2(q_j + q_k)}{25t - 8v^2} \tag{A.14}$$

The second order condition is satisfied for $t > \frac{8}{25}v^2$. Qualities are strategic substitutes ($\frac{\partial q_i}{\partial q_j} < 0$ and $\frac{\partial q_i}{\partial q_k} < 0$).

In the first stage we have the following symmetric equilibrium consumer price, quality and profit

$$\begin{aligned} p^{sh} &= \frac{t}{n} - b \\ q^{sh} &= \frac{4v}{5n} \\ \pi^{sh} &= \frac{1}{9}\left(t - \frac{8v^2}{25}\right) \end{aligned} \tag{A.15}$$

Single-homing: Equilibrium outcomes after a merger

In the second stage we have the same first order condition for consumer price as in (3.11) for the merged platforms, and the first order condition from (3.4) for the outside platform. This yields the following reaction functions for consumer price

$$p_1 = \frac{t}{3} + \frac{v(2q_1 - q_2 - q_3) + p_3 - b}{2} \tag{A.16a}$$

$$p_2 = \frac{t}{3} + \frac{v(2q_2 - q_1 - q_3) + p_3 - b}{2} \tag{A.16b}$$

$$p_3 = \frac{t}{6} + \frac{v(2q_3 - q_2 - q_1) + p_1 + p_2 - 2b}{4} \tag{A.16c}$$

The second order condition is satisfied for $t > 0$. These best response functions yield the following equilibrium consumer prices in the second stage

$$p_1 = \frac{5}{9}t + \frac{v(11q_1 - 7q_2 - 4q_3)}{12} - b \tag{A.17a}$$

$$p_2 = \frac{5}{9}t + \frac{v(11q_2 - 7q_1 - 4q_3)}{12} - b \tag{A.17b}$$

$$p_3 = \frac{4}{9}t + \frac{v(2q_3 - q_2 - q_1)}{6} - b \tag{A.17c}$$

From maximising the joint equilibrium profit from the second stage for the merged platforms and the equilibrium profit for the outside platform we find the following best response functions for quality in the first stage

$$q_1 = q_2 = q_m = \frac{5tv - 3v^2 q_3}{3(9t - v^2)} \tag{A.18a}$$

$$q_3 = q_o = \frac{8tv - 3v^2(q_1 + q_2)}{3(9t - 2v^2)} \tag{A.18b}$$

The second order condition holds for $t > \frac{2}{9}v^2$. We then have the following asymmetric equilibrium qualities, consumer prices, demands and profits

$$\begin{aligned} q_m^{sh} &= \frac{v(5t - 2v^2)}{9(3t - v^2)} \\ p_m^{sh} &= \frac{t(5t - 2v^2)}{3(3t - v^2)} - b \\ \pi_m^{sh} &= \frac{(5t - 2v^2)^2(9t - v^2)}{162(3t - v^2)^2} \\ D_m^{sh} &= \frac{5t - 2v^2}{6(3t - v^2)} \end{aligned} \tag{A.19}$$

$$\begin{aligned} q_o^{sh} &= \frac{2v(4t - v^2)}{9(3t - v^2)} \\ p_o^{sh} &= \frac{t(4t - v^2)}{3(3t - v^2)} - b \\ \pi_o^{sh} &= \frac{(4t - v^2)^2(9t - 2v^2)}{81(3t - v^2)^2} \\ D_o^{sh} &= \frac{4t - v^2}{3(3t - v^2)} \end{aligned} \tag{A.20}$$

For this to be an equilibrium we need $t > \frac{2}{5}v^2$.

Single-homing: Calculation of condition for merger profitability

$$2\pi_m^{sh} - 2\pi^{sh} = \frac{44\,v^6 + 86\,tv^4 - 1129\,t^2v^2 + 1575\,t^3}{4050\,\left(3\,t - v^2\right)^2} \tag{A.21}$$

A merger is profitable if $t > \psi$, where

$$\psi = \left(\frac{(1825811972 + 880875\sqrt{28521433})^{\frac{2}{3}} + 6863(1825811972 + 880875\sqrt{28521433})^{\frac{1}{3}} - 265881}{19575(1825811972 + 880875\sqrt{28521433})^{\frac{1}{3}}} \right) v^2 \tag{A.22}$$

We use the merger profitability condition to compare the pre-merger symmetric equilibrium with $n = 3$ and the asymmetric equilibrium

$$\begin{aligned} q_m^{sh} - q^{sh} &= -\frac{v(2v^2 - 11t)}{45(3t - v^2)} \quad < 0 \\ q_o^{sh} - q^{sh} &= \frac{2v(v^2 - 2t)}{45(3t - v^2)} \quad > 0 \\ p_o^{sh} - p^{sh} &= \frac{t^2}{3(3t - v^2)} \quad > 0 \end{aligned} \tag{A.23}$$

While the change in average quality is

$$\bar{q}_{after}^{sh} - \bar{q}_{before}^{sh} = \frac{2q_m^{sh} + q_o^{sh}}{3} - \frac{3q^{sh}}{3} = -\frac{2v}{15} \quad < 0 \tag{A.24}$$

For the merged platforms we find that the change in consumer price after a merger is dependent on an interval for t

$$p_m^{sh} - p^{sh} = \frac{t(4t - 3v^2)}{9(2t - v^2)} \begin{cases} < 0 \; if & \psi < t < \frac{1}{2} \\ > 0 \; if & t > \frac{1}{2}v^2 \end{cases} \tag{A.25}$$

Multi-homing: Best response functions and equilibrium outcomes

For the second stage we have the same first order condition for consumer price as in (3.25). This yields the following reaction function for consumer price for platform i

$$p_i(q_i) = p_i^{sh} = \frac{\gamma v(1 + q_i) - \phi b}{2} \tag{A.26}$$

As with simultaneous timing, the second order condition holds for $\gamma > 0$ and $t > 0$. The result of strategic independence for consumer prices is the same as in simultaneous timing, and (A.26) is also the symmetric equilibrium consumer price in the second stage.

For the first stage, we have the following reaction function for quality for platform i

$$q_i^{sh} = \frac{v(\phi b + \gamma v)}{t - \gamma v^2} \tag{A.27}$$

The second order condition holds for $t > \gamma v^2$. The result for strategic independence for quality is the same as in simultaneous timing, and (A.27) is also the symmetric equilibrium quality in the first stage, which is the same consumer quality as the simultaneous symmetric equilibrium in (3.28).

Using the symmetric equilibrium quality in the first stage from (A.27), back in the equilibrium consumer price in the second stage from (A.26) we find the symmetric equilibrium consumer price in the first stage

$$p^{mh} = \frac{\phi b(2\gamma v^2 - t) + t\gamma v}{2(t - \gamma v^2)} \tag{A.28}$$

which is the same consumer price as the simultaneous symmetric equilibrium in (3.28). As the symmetric equilibrium consumer price and quality for sequential timing is the same as in simultaneous timing, it will yield the same symmetric equilibrium profit, total demand, single-homing demand and multi-homing demand as in (3.29)-(3.31).

Single-homing: Welfare

The consumer surplus in the symmetric equilibrium with $n = 3$ platforms is as follows

$$CS_b^{sh} = v + \frac{4}{15}v^2 - \frac{5}{12}t + b \tag{A.29}$$

The consumer surplus after a merger is given by

$$CS_m^{sh} = \frac{8v^6 + 36v^5 + v^4(36b - 71t) - 216tv^3 + v^2(206t^2 - 216bt) + 324t^2v + 324bt^2 - 193t^3}{36(3t - v^2)^2} \tag{A.30}$$

This yields the following change in consumer surplus

$$\Delta CV^{sh} = CS_m^{sh} - CS_b^{sh} = \frac{4v^4(t - v^2) + 74t^2v^2 - 145t^3}{90(3t - v^2)^2} \tag{A.31}$$

We impose the merger profitability condition, which gives us the following

$$\Delta CS^{sh} = \begin{cases} > 0 \; if & \psi < t < \xi \\ < 0 \; if & t > \xi \end{cases} \tag{A.32}$$

here ψ is from (A.22) and

$$\xi = \left(\frac{(870I\sqrt{115455} - 536986)^{\frac{2}{3}} + 74(870I\sqrt{115455} - 536986)^{\frac{1}{3}} + 7216}{435(870I\sqrt{115455} - 536986)^{\frac{1}{3}}} \right) v^2 \tag{A.33}$$

The advertiser surplus both before and after a merger is equal to zero

$$\Delta AS^{sh} = AS_m^{sh} - AS_b^{sh} = 0 \tag{A.34}$$

The platform surplus in the symmetric equilibrium is the following

$$PS_b^{sh} = \frac{t}{3} - \frac{8v^2}{75} \tag{A.35}$$

The platform surplus after a merger is given by

$$PS_m^{sh} = \frac{27tv^4 - 2v^6 - 103t^2v^2 + 123t^3}{27(3t - v^2)^2} \tag{A.36}$$

This yields the following change in producer surplus

$$\Delta PS^{sh} = PS_m^{sh} - PS_b^{sh} = \frac{22v^6 + 18tv^4 - 577t^2v^2 + 1050t^3}{675(3t - v^2)^2} > 0 \tag{A.37}$$

This expression is positive for $t > \psi$.

Using (A.31), (A.34) and (A.37) we find that the total change in welfare as a result of a merger under single-homing with sequential timing is:

$$\Delta W^{sh} = \Delta CS^{sh} + \Delta AS^{sh} + \Delta PS^{sh} = \frac{16v^4(6t - v^2) - 44t^2v^2 - 75t^3}{1350(3t - v^2)^2} < 0 \tag{A.38}$$

The change in welfare is negative for $t > \psi$.

A4 Alternative Formulations

A4.1 Single-Homing

We attempted to incorporate the product functionality formulation from Anderson et al. (2017) in our model. When there are only single-homing consumers in the market, the utility of the consumers located at x buying from platform i is given by

$$u_i = (v - t|x_i - x|)q_i - p_i$$

The demand faced by platform i is then

$$D_i = \frac{q_j}{n(q_i + q_j)} + \frac{v(q_i - q_j) - (p_i - p_j)}{t(q_i + q_j)} + \frac{q_k}{n(q_i + q_k)} + \frac{v(q_i - q_k) - (p_i - p_k)}{t(q_i + q_k)} \tag{A.39}$$

When the platforms simultaneously choose consumer prices and functionalities, they choose q_i and p_i to maximise the same profit function as (3.3), which yields the same first order conditions as in (3.4). However, using the demand from (A.39) yields the following best response functions for consumer prices and functionalities:

$$p_i = \frac{2v(q_i^2 + q_j q_k) + p_k(q_i + q_j) + p_j(q_i + q_k)}{2(2q_i + q_j + q_k)} + \frac{t\,(2q_j q_k + q_i(q_j + q_k))}{2(2q_i + q_j + q_k)n} - \frac{b}{2} \tag{A.40}$$

$$\begin{aligned} q_i = & \frac{2\sqrt{-(q_j - q_k)^2\left((vq_j + \frac{p_i}{2} - \frac{p_j}{2})n - \frac{tq_j}{2}\right)\left((vq_k + \frac{p_i}{2} - \frac{p_k}{2})n - \frac{tq_k}{2}\right)}}{(2v(q_j + q_k) + 2p_i - p_j - p_k)n - t(q_j + q_k)} \\ & + \frac{n\,(p_k q_j + p_j q_k - 4v q_j q_k - p_i(q_j + q_k)) + 2t q_j q_k}{(2v(q_j + q_k) + 2p_i - p_j - p_k)n - t(q_j + q_k)} \end{aligned} \tag{A.41}$$

These best response functions, functionality in particular, do not illustrate much economic intuition. Moreover, the mathematical tool made available to us was not able to solve (A.40)-(A.41) simultaneously, so we were not able find an equilibrium.

We experimented with the same formulation but with sequential choice of consumer prices and functionalities. In the second stage, this yields the same reaction function for consumer price as in (A.40). However, it yields the following equilibrium consumer price in the second stage

$$p_i = \frac{2\,nvq_j^{\,4} + (17\,tq_i + (-12\,nv + 21\,t)\,q_k - 20\,bn)\,q_j^{\,3}}{n(8q_j^{\,3} + (39\,q_i + 51\,q_k)\,q_j^{\,2} + (32\,q_i^{\,2} + 110\,q_iq_k + 54\,q_k^{\,2})\,q_j + (5\,q_i^{\,3} + 43\,q_i^{\,2}q_k + 46\,q_iq_k^{\,2} + 12\,q_k^{\,3}))}$$
$$+ \frac{\left((10\,nv + 26\,t)\,q_i^{\,2} + ((-14\,nv + 70\,t)\,q_k - 51\,bn)\,q_i + (-24\,nv + 44\,t)\,q_k^{\,2} - 35\,bnq_k\right)q_j^{\,2}}{n(8q_j^{\,3} + (39\,q_i + 51\,q_k)\,q_j^{\,2} + (32\,q_i^{\,2} + 110\,q_iq_k + 54\,q_k^{\,2})\,q_j + (5\,q_i^{\,3} + 43\,q_i^{\,2}q_k + 46\,q_iq_k^{\,2} + 12\,q_k^{\,3}))}$$
$$+ \frac{\left((12\,nv + 13\,t)\,q_i^{\,3} + ((20\,nv + 61\,t)\,q_k - 52\,bn)\,q_i^{\,2}\right)q_j}{n(8q_j^{\,3} + (39\,q_i + 51\,q_k)\,q_j^{\,2} + (32\,q_i^{\,2} + 110\,q_iq_k + 54\,q_k^{\,2})\,q_j + (5\,q_i^{\,3} + 43\,q_i^{\,2}q_k + 46\,q_iq_k^{\,2} + 12\,q_k^{\,3}))}$$
$$+ \frac{\left(\left((-16\,nv + 72\,t)\,q_k^{\,2} - 86\,bnq_k\right)q_i + (-12\,nv + 20\,t)\,q_k^{\,3} - 30\,bnq_k^{\,2}\right)q_j}{n(8q_j^{\,3} + (39\,q_i + 51\,q_k)\,q_j^{\,2} + (32\,q_i^{\,2} + 110\,q_iq_k + 54\,q_k^{\,2})\,q_j + (5\,q_i^{\,3} + 43\,q_i^{\,2}q_k + 46\,q_iq_k^{\,2} + 12\,q_k^{\,3}))}$$
$$+ \frac{4\,nvq_i^{\,4} + ((18\,nv + 12\,t)\,q_k - 17\,bn)\,q_i^{\,3}}{n(8q_j^{\,3} + (39\,q_i + 51\,q_k)\,q_j^{\,2} + (32\,q_i^{\,2} + 110\,q_iq_k + 54\,q_k^{\,2})\,q_j + (5\,q_i^{\,3} + 43\,q_i^{\,2}q_k + 46\,q_iq_k^{\,2} + 12\,q_k^{\,3}))}$$
$$+ \frac{\left((12\,nv + 28\,t)\,q_k^{\,2} - 51\,bnq_k\right)q_i^{\,2} + \left(-46\,bnq_k^{\,2} + 16\,tq_k^{\,3}\right)q_i - 12\,bnq_k^{\,3}}{n(8q_j^{\,3} + (39\,q_i + 51\,q_k)\,q_j^{\,2} + (32\,q_i^{\,2} + 110\,q_iq_k + 54\,q_k^{\,2})\,q_j + (5\,q_i^{\,3} + 43\,q_i^{\,2}q_k + 46\,q_iq_k^{\,2} + 12\,q_k^{\,3}))}$$

Using this somewhat unattractive expression for equilibrium consumer price yields even less attractive expressions for equilibrium demand and profit, which are too long to be repeated in this appendix. With this in mind, we suspected that the best response functions for functionalities in the first stage might not give too much economic intuition. Actually, when trying to find the best response function from maximising the equilibrium profit from stage two with respect to functionality, it yielded expressions where our mathematical tool was not able to isolate an expression for q_i. Hence, we were not able to find an equilibrium with either simultaneous or sequential choice of consumer prices and functionalities for this way of formulating quality under single-homing.

A4.2 Multi-Homing

For our multi-homing model, our first attempt was to implement the same way of modelling the incremental value as in Anderson et al. (2017). When there are multi-homing consumers, we assume that the incremental value from purchasing access to platform 2 in addition to platform 1 is given by

$$u_{12} = (v - t|x_2 - x_{12}|)\,V_{12} - p_2$$

$V_{12} = q_2 - \beta q_1 q_2$ is the incremental valuation of buying access to the second platform. Using this way of modelling the incremental value, we would be able to account for the possible disutility for the multi-homing consumer from the overlapping functionalities between the two platforms she is buying access to, measured by $\beta \in [0, 1]$.

To find the single-homing, multi-homing and total demand faced for platform 1, we use the same approach as we did to find (3.21)-(3.23) in our model. When $n = 3$, this yields

$$\begin{aligned} x_1^{sh} &= \frac{2}{n} - \frac{1}{t}\left[2v - \frac{1}{1-\beta q_1}\left(\frac{p_2}{q_2} + \frac{p_3}{q_3}\right)\right] \\ D_1 &= \frac{1}{t}\left[2v - \frac{p_1}{q_1}\left(\frac{1}{1-\beta q_2} + \frac{1}{1-\beta q_3}\right)\right] \\ x_1^{mh} &= \frac{1}{t}\left[4v - \frac{p_1}{q_1}\left(\frac{1}{1-\beta q_2} + \frac{1}{1-\beta q_3}\right) - \frac{1}{1-\beta q_1}\left(\frac{p_2}{q_2} + \frac{p_3}{q_3}\right)\right] - \frac{2}{n} \end{aligned} \tag{A.42}$$

When the platforms simultaneously choose consumer prices and functionalities, they choose q_i and p_i to maximise the same profit function as (3.24), which yields the same first order conditions as in (3.25). However, using the demands from (A.42) yields the following best response functions for consumer price of platform 1:

$$p_1 = \frac{\left(vq_1 - \frac{\phi b}{2}\right)(q_2 + q_3)\beta - v(\beta^2 q_1 q_2 q_3 + q_1) + \phi b}{\beta(q_2 + q_3) - 2} \tag{A.43}$$

Notice, the best response function for consumer prices does not illustrate much economic intuition. Furthermore, we do not obtain a best response function for functionalities as each term of the first order condition is dependent on own functionality level. Hence, we were not able to obtain an equilibrium.

We experimented with sequential timing to see whether we could find an equilibrium for functionality levels in the first stage. The second stage yields the same best response function for consumer price as in (A.43). Due to the strategic independence between consumer prices of the platforms, it is also the equilibrium consumer price in the second stage. Using this to maximise the equilibrium profit from the second stage to find the best response functions for functionalities in the first stage, we encounter another problem. The equilibrium consumer price from (A.43) yields very unattractive expressions for equilibrium demands and profit. This in turn yields, as with simultaneous timing, first order conditions where each term is dependent on own functionality level. Hence, we were not able to obtain an equilibrium for functionalities in the first stage.

We tried to somewhat simplify the formulation for incremental value of the second purchase from Anderson et al. (2017). For a multi-homing consumer who decides to buy access to platform 2 in addition to platform 1, the incremental value is given by

$$u_{21} = (v - t|x_2 - x_{12}|)\,\theta q_2 - p_2$$

θq_2 is meant to capture that the incremental value of purchasing access to platform 2 as well as platform 1 is increasing in the functionality level of platform 2. Here $\theta \in [0, 1]$ is a measure of the disutility from overlapping functionalities. With this way of modelling, the platforms are not able to affect the disutility of overlapping functionalities.

To find the single-homing, multi-homing and total demand faced for platform i, we use the same approach as we did to find (3.21)-(3.23) in our model. This yields

$$\begin{aligned} x_i^{sh} &= \frac{2}{n} - \frac{1}{t\theta}\left[2v\theta - \frac{p_j}{q_j} - \frac{p_k}{q_n}\right] \\ D_i &= \frac{2}{t\theta}\left[v\theta - \frac{p_i}{q_i}\right] \\ x_i^{mh} &= \frac{1}{t\theta}\left[4v\theta - \frac{2p_i}{q_i} - \frac{p_j}{q_j} - \frac{p_k}{q_k}\right] - \frac{2}{n} \end{aligned} \tag{A.44}$$

When the platforms simultaneously choose consumer prices and functionalities, they choose q_i and p_i to maximise the same profit function as (3.24), which yields the same first order conditions as in (3.25). However, using the demands from (A.44) yields the following best response functions for consumer prices and functionalities:

$$p_i = \frac{v\theta\, q_i}{2} - \frac{\phi b}{2} \tag{A.45}$$

$$q_i = \frac{\sqrt[3]{2}}{t\theta}\sqrt[3]{p_i\,(\phi b + p_i)\, t^2\theta^2} \tag{A.46}$$

The best response function for functionalities do not illustrate much economic intuition. Moreover, the mathematical tool made available to us was not able to solve (A.45)-(A.46) simultaneously, so we were not able find an equilibrium.

We experimented with sequential choice for consumer prices and functionalities to see whether we could find an equilibrium for functionality levels in the first stage for this somewhat simplified way of modelling the incremental value. The second stage yields the same best response consumer price as in (A.45). Due to the strategic independence between consumer prices of the platforms, it is also the equilibrium consumer price in the second stage. Using this to maximise the equilibrium profit from the second stage we found the following best response functions for functionalities in the first stage

$$\begin{aligned} q^{mh} =& \frac{\sqrt[3]{\left(\theta^4 v^6 - 54\,\phi b^2 t^2 + 6\,\sqrt{3}\phi b\,\sqrt{-\theta^4 v^6 + 27\,\phi b^2 t^2}t\right)\theta^2}}{6\,t\theta} \\ &+ \frac{\theta^3 v^4}{6\,t\sqrt[3]{\left(\theta^4 v^6 - 54\,\phi b^2 t^2 + 6\,\sqrt{3}\phi b\,\sqrt{-\theta^4 v^6 + 27\,\phi b^2 t^2}t\right)\theta^2}} + \frac{\theta\,v^2}{6\,t} \end{aligned} \tag{A.47}$$

Due to the strategic independence for functionalities between the platforms, this is also the equilibrium functionalities in the first stage. Using this back in (A.45) we found the following equilibrium consumer price in the first stage

$$\begin{aligned} p^{mh} =& \frac{v\theta}{2}\left(\frac{\sqrt[3]{\left(\theta^4 v^6 - 54\,\phi b^2 t^2 + 6\,\sqrt{3}\phi b\,\sqrt{-\theta^4 v^6 + 27\,\phi b^2 t^2}t\right)\theta^2}}{6\,t\theta}\right) \\ &+ \frac{v\theta}{2}\left(\frac{\theta^3 v^4}{6\,t\sqrt[3]{\left(\theta^4 v^6 - 54\,\phi b^2 t^2 + 6\,\sqrt{3}\phi b\,\sqrt{-\theta^4 v^6 + 27\,\phi b^2 t^2}t\right)\theta^2}}\right) \\ &+ \frac{\theta^2\,v^3}{12\,t} - \frac{\phi b}{2} \end{aligned} \tag{A.48}$$