NYOP and price competition:

How NYOP can avoid a race to the bottom

Master's thesis Economics & Business Economics
Specialisation: Marketing

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Rotterdam, September 2017

Abstract:
This master's thesis examines the strategical implications of the name-your-own-price (NYOP) and posted pricing strategy in a monopoly and duopoly market, while taking into account the strategic actions of customers with regard to their bidding strategy. A duopoly model with complete information is designed in order to derive the optimal strategy of retailers under price competition. It is found that both retailers should prefer NYOP. This thesis concludes that NYOP can avoid pricing competition in a market where retailers compete on price. The assumptions of the model are tested with an experiment.

KEYWORDS: NYOP, posted pricing strategy, price competition, game theory, monopoly, duopoly, experiment.

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Section 1. Introduction

1.1 Problem statement and research question

Price competition is a dangerous business. It may easily lead to price wars, especially in markets where prices are the main element of competition (Krämer et al., 2016).

How does a price war arise? Imagine a market with two retailers, A and B, offering an identical product. As the quality of the product does not differ among the retailers, the customers will buy the product from the retailer offering the lowest price. If we assume that the current market price is 10 euro for the product, then the customer is indifferent between the products and buys at either one of the retailers: the total demand is divided over the two retailers. If the total production cost per product is 5 euro for both retailers, both earn a profit of 5 euro per product while serving half the market. At one moment, however, retailer A, realises that he could lower his price somewhat while still making a profit. If he lowers his price, while retailer B does not, all customers will buy from A as he offers the lowest price. In this case retailer A earns a lower profit per product but has a higher total profit as he now serves the entire market. This induces a price war.

An illustration: A lowers his price to, for example, 7 euros. All customers now buy the product from retailer A. Retailer A makes a profit of 2 euros times the quantity sold in the market. The other retailer sells nothing. Thus, retailer B must also lower his price. If retailer B lowers his price to 7 euros, both retailers again sell an equal amount, however, now for a price of 7 instead of 10 euro. If retailer B however realises that he could attract all the demand if he sets his price lower than 7 euros, he could make a bigger profit for a short time. Retailer A then serves no one as his price is too high. To attract market demand, he will lower the price again below the price that retailer B offers. This results to a race to the bottom. This race to the bottom continues until the marginal costs per product are reached and both retailers make zero profits (Frank, 2010). The retailers will not set prices below marginal costs, as that would lead to a loss per product sold, and to bankruptcy in the long run. This market is also called a Bertrand duopoly, because retailers compete on price (Frank, 2010).

Price competition as described above results to zero-profits for the retailers (Krämer et al., 2016). This makes us wonder whether there is a pricing strategy, instead of the posted prices, that does not result in a race to the bottom and subsequently enables retailers to make a profit.

Name-your-own-price (NYOP) is a different pricing strategy that might prevent such a downwards spiral. With a NYOP pricing strategy, the retailer does not set a posted price. Instead, the retailer sets a (for the customer unknown) threshold and lets the customer bid on his products (Hinz et al., 2011). The bid is accepted when the bid exceeds the threshold set by the retailer (Hinz et al., 2011). If the bid is accepted, the customer buys the product for the price of the bid. When the bid is rejected, the customer cannot buy the product. NYOP hides the price and avoids that the other retailer pulls the trigger and starts a price war.

However, a negative aspect of the NYOP pricing strategy is its dependency on the behaviour of customers: if only the price matters for customers, customers may act strategically if retailers use different pricing mechanisms. For example, if two retailers have posted prices, customers buy from the retailer with the lowest price; if one retailer has posted prices and the other retailer has a NYOP pricing strategy, customers may use the posted price of the retailer as a guideline and bid a lower price at the NYOP retailer; and if both retailers have a NYOP pricing strategy, customers may use a trial-and-error method to find the lowest possible price.

By not setting posted prices, publically known by customers and competitors, NYOP basically hides the price of the retailer. Therefore, in a market where prices are the main element of competition, NYOP may be capable of avoiding heavy price competition as a retailer cannot start a price war by lowering its price below that of the competitor. However, the strategic behaviour of customers on the NYOP pricing strategy should be taken into account when evaluating the profitability of the NYOP pricing strategy. Therefore, this thesis answers the following research question:

How are the profits of retailers influenced when they use a NYOP pricing strategy instead of a posted pricing strategy in a duopoly market, while taking into account possible strategic actions of customers?

1.2 Academic and managerial relevance

1.2.1 Academic relevance

This thesis integrates the literature on price competition and the literature on customer behaviour by relaxing the assumption of a uniform distribution for the valuation of a customer for a product in a price competition model. Anderson and Wilson (2011) suggest that the literature on NYOP could be extended by incorporating competition in models that focus on customer behaviour. The literature on strategic behaviour of customers regarding pricing strategies is more extensive than the literature on the strategic actions of retailers (Spann & Tellis, 2006; Amaldoss & Jain, 2008). However, none of the customer behaviour literature takes competition between retailers into account. Literature on competition between retailers sometimes model customer behaviour, however, the assumptions made regarding customers are not realistic.

Furthermore, Anderson and Wilson (2011) suggest that theoretical models on retailer competition can be improved by relaxing the assumption that customers bid uniformly. This thesis adds to the literature by implementing an extended version of the model of customer behaviour by Easley and Kleinberg (2010) within a dynamic game with perfect information between retailers. However, instead of a uniform bidding function as assumed by Easley and Kleinberg (2010), this thesis will implement a non-uniform bidding function in order to model the strategic customer behaviour.

This thesis is closely related to two papers. Firstly, the theoretical framework is designed using the same method as Samahita (2015). She uses a dynamic game with perfect information to determine the effect of a pay-what-you-want (PWYW) pricing strategy on competition in a Bertrand duopoly market. In this type of game, retailers move after each other and observe the moves that are made. A monopoly model is constructed following Samahita (2015), then it is extended into a duopoly model; in contrast to Samahita (2015), this thesis researches a NYOP pricing strategy, and not an PWYW strategy. Secondly, this thesis incorporates the model of Fay (2009). He uses a dynamic game with perfect information to research the effect of choosing a NYOP strategy when a competitor, already active in the market, uses a posted-price strategy. This thesis also uses a dynamic game with perfect information. However, in contrast to Fay (2009) who uses uniform bidding functions, this thesis implements non-uniform bidding functions to model the bidding behaviour of the customers.

1.2.2 Managerial relevance

This research is relevant for retailers that compete on price with one or more competitors (Spann & Tellis, 2006). This thesis helps the managers of retail companies with strategic decision-making regarding pricing strategies in several ways. Firstly, by deciding what pricing strategy to take, the possible actions of the competitor are considered. Taking into account the decision of the competitor leads to a better strategic decision as possible counter reactions of the competitor can be anticipated on. Furthermore, the research can be extended and have implications for a market with more than two competitors (Tadelis, 2013). Secondly, the model also takes the strategic decision-making of customers into account. This is important for the manager, as actions of customers influence the profitability of NYOP and posted pricing strategy. This thesis, therefore, supports managers in the decision-making process on *whethe*r to implement a NYOP or a posted pricing strategy and *what* the profit would be, taking into account the actions of the competitor and customers.

This thesis is especially relevant for online retailers. Due to practical reasons, NYOP is easiest implemented in an online environment. Strategic behaviour by customers, such as trial-and-error repeated bidding in order to find out the lowest accepted price, leads to lower profits for the retailer. This behaviour, however, could be avoided by online customers registration, allowing bids only in certain time intervals or by varying the set threshold (Terwiesch et al., 2005; Fay & Laran, 2009). From the perspective of the customer, NYOP is also more convenient online as customers do not have to travel to the physical store to place a bid. An online system makes NYOP more efficient; registration, bidding and rejection of bids results is a lot of paperwork, especially when a lot of customers participate. A digital, automatic system would make NYOP system feasible.

1.3 Structure of the thesis

In the next section, we review the literature. In section 3 we discuss the theoretical framework. Thereafter, in section 4, we explain the basic model in a monopoly setting. In section 5, the model is extended to a duopoly market with two retailers in a dynamic game with perfect information. In section 6, we discuss the set-up and the results of an experiment on the assumptions of the model. In the final section, we answer the research question, give implications for managers and researchers, and give limitations of the research and suggestions for future research.

Section 2. Literature review

This thesis models the strategic actions of retailers, while taking into account the strategic actions of customers. Therefore, there are two relevant research areas in the literature. The first stream of literature focuses on the strategic actions of retailers. The second stream focuses on the strategic actions of customers on the NYOP pricing strategy. In this section, we discuss the most relevant literature of both streams.

2.1 Literature on retailer-retailer interaction

2.1.1 Competition between retailers

Fay (2004) theoretically explores the profitability of the NYOP pricing strategy in a monopoly market. He shows that the posted pricing strategy weakly dominates NYOP in his framework. However, based on his research Fay (2004) suggests that NYOP may soften competition in a duopoly market, because prices are less visible. In his follow-up 2009 paper, Fay extended his research to a duopoly market. In this paper, he argues that NYOP can help soften competition in a duopoly market by solving a dynamic game. His game consists of two stages. Fay (2009) created a game consisting of two stages: in the first stage, the retailers decide what pricing strategy to use: NYOP or posted prices. In the second stage, the retailer that chose a posted pricing strategy sets its prices. The customer then decides where to buy the product. The price competition was reduced due to differences in frictional costs of customers, i.e. the shopping hassle of placing a bid at the NYOP retailer. Due to this, the NYOP retailer targets the customers with low frictional costs, while the posted pricing retailer targets the customers with high frictional costs.

Krämer et al. (2015) investigate under which circumstances a retailer should implement a NYOP or a PWYW strategy. They confirm the finding by Fay (2009) that NYOP reduces price competition, due to the fact that the NYOP retailer does not set a fixed price. Based on their theoretical model, Krämer et al. (2015) made predictions regarding the NYOP pricing strategy and tested them in a controlled lab experiment. Firstly, they predicted that that the NYOP retailer sets an optimal threshold. The experiment showed that retailers learn to lower their threshold over time and thus learn to set their threshold optimally as they gain experience. Secondly, they predicted that NYOP segments the market in customers with high and low valuations. The NYOP retailer will focus on the customers with a low valuation, while the posted price retailer will focus on the customers with a high valuation. This segmentation reduces price competition as well. This prediction was confirmed in their experiment. Finally, they predicted that the NYOP retailer makes positive profits on average and have a higher expected market share. They also predicted that when a retailer was given the choice, he prefers the NYOP pricing strategy over the posted pricing strategy. These predictions were confirmed by their experiment.

Chen et al. (2014) analyse NYOP and posted prices from the perspective of service providers. Service providers, as additional player in the market, sell their excess capacity to a retailer. The paper also evaluates whether a retailer prefers NYOP or posted prices when there is another retailer in the market. When there is no competition for the retailer, they show that the retailer prefers NYOP; when the retailer has a competitor, they find that both retailers have a preference for posted prices, in contrast with Krämer et al. (2015).

Samahita (2015) researches PWYW instead of NYOP, but she finds that PWYW can avoid price competition. The main difference between PWYW and NYOP is the threshold set under NYOP. With the NYOP pricing strategy, the retailer can make sure that products are not sold below the marginal costs, that is, he can avoid products being sold at a loss. This is not the case with the PWYW pricing strategy, as products are sold at any bid. As this is the only difference between PWYW and NYOP, Samahita's result with regard to PWYW may be an indication that NYOP can avoid or soften price competition as well. Samahita (2015) models the effects of the PWYW pricing scheme on competition using a monopoly market and a duopoly market. She finds two equilibria: in the first case, both retailers use posted pricing strategies; in the second equilibrium, one retailer choses PWYW to avoid price competition. She concludes that choosing a PWYW pricing strategy is desired as the retailer in the market differentiates himself and therefore avoids heavy price competition.

2.2 Literature on retailer-customer interaction

We discuss the literature on retailer-customer interaction in three parts. Firstly, we evaluate literature regarding strategic thinking; then literature focussing on bidding patterns; and finally, we review whether allowing for multiple bids would be profit enhancing for retailers.

2.2.1 Strategic thinking of retailers and customers

Hinz (2007) theoretically explores the strategic behaviour of customers and retailers simultaneously, such that the strategic interaction effects are taken into account. He uses a bargaining game extended with an agent-based simulation. The aim of Hinz's paper is to find how the retailer could set the threshold price optimally and how customers bid strategically. He finds that the retailer would always set the threshold very close to his variable costs, while the best strategy for the customer is to anticipate on this and place a bid, which is based on the beliefs about the retailer's costs. Regarding strategic customer behaviour, Hinz (2007) finds that when customers can estimate the seller's costs accurately and with low uncertainty, bids of customers are primarily based on the assessment of the retailers' costs. Furthermore, Hinz (2007) states that this leads to sub-optimal price discrimination as the customers almost pay a price equal to marginal costs, which results in lower profits for the retailer. Therefore, he suggests that NYOP should only be applied in markets where there is high uncertainty about the costs of the retailer.

Voigt and Hinz (2014) use a game theoretic and empirical analysis to look into the strategic learning and interaction effects between customers and the NYOP retailer. They argue that if players behave as (game) theory suggests, retailers set their threshold closely to their marginal costs. When a customer anticipates to this strategy of the retailers, the customer lowers his bid, such that his surplus increases. In the long run, this may lead to a very small margin for the retailer. Therefore, they argue that the retailer might not have an incentive to use the NYOP pricing strategy.

Voigt and Hinz (2014) also conducted a laboratory experiment. They found that retailers indeed quickly learn to lower their threshold, which increases the total surplus. Customers learn that they can successfully bid lower prices over time. The bids of the customers are mainly based on their expectation of the retailers' costs, and not on their willingness to pay. This is in agreement with their theoretical model. However, another result is that customers are risk averse and are therefore less willing to face the risk of a very low bid and not obtaining the product. Because of the risk averseness of customers, they state that NYOP is can be a sustainable pricing mechanism, even in the long run.

Hann and Terwiesch (2003) find in an empirical study on bidding strategies of customers that optimal bidding behaviour depends on the customer's belief of the threshold price and on their maximum willingness to pay. This belief about the threshold is uniformly distributed on an interval.

2.2.2 Bidding patterns of customers

Spann and Tellis (2006) matched theoretical optimal bidding patterns with data obtained from a German NYOP retailer. The researchers found that customer faced with positive bidding costs, have a concavely increasing bidding pattern. They state that this is because of the fact that the customer wants to increase the probability that he wins the product. However, when the bid comes closer to the maximum price the customer wants to pay, the rate of which the bids are increasing slows down. When the customer faces no bidding costs, it is shown that the bidding pattern should be linearly increasing. When Spann and Tellis (2006) match their theoretical outcome with data. They find that only 35% fits the concavely increasing bidding pattern and 5% fits the linearly increasing bidding pattern. 23% matches a convexly increasing pattern, which leads them to conclude that customers behave rather irrational on the Internet. Regarding competition, the researchers state price discovery mechanisms, such as NYOP, reduce competition as other retailers (using posted prices) do not know the price of their NYOP competitor and thus cannot respond by lowering their own prices.

Contrary to Spann and Tellis (2006), Chen (2012) find that convexly increasing bidding paths could be fully rational. He investigates the NYOP strategy of Priceline.com regarding strategic bidding and lockout periods. A lockout period is a waiting period between successive bids of the customer. The model used consists of a dynamic model with a customer and two or more NYOP retailers. In the model, the buyer announces a bid to all retailers. When the bid is accepted by one of the retailers in the market, the game ends. Chen (2012) finds two equilibria in the case where there are no lockout periods. Both equilibria show different bidding paths of customers. Firstly, he finds a fully screening equilibrium, where the customer keeps raising the bids until a retailer accepts the bid. Secondly, he finds a price ceiling equilibrium, where the buyer keeps the bids close to the bid that was accepted earlier by the retailer with the lowest costs. When the end of the game approaches, the customer anticipates on the coming end and raises bids, reaching a price ceiling. The price ceiling equilibrium has a convexly increasing bidding path, and, is in contrast with the findings of Spann and Tellis (2006), fully rational in the model of Chen (2012). He motivates that the price ceiling equilibrium is related to the deadline effect. The deadline effect is the (experimental) observation where most agreements in bargaining settings are reached towards the end of the bargaining deadline (Roth et al., 1988).

2.2.3 Multiple bids by customers

Spann et al. (2004) analyse the effect of allowing the customer to make multiple bids on the willingness to pay of that customer and the profit of the retailer. They find that in a single-bid NYOP model, the optimal bid is always lower than the optimal bid in a two-bid NYOP model. Therefore, they conclude that allowing repeated bidding result in higher profit margins for the seller, than when the NYOP retailer only allows one bid per customer.

Fay (2004) also finds that allowing rebidding could enhance the profits of the NYOP retailer. However, the increase of profits depends on the behaviour of customers: if they strategically rebid to get a lower bid accepted, the profit would increase less.

2.3 Overview of literature

Table 1 gives an overview of the literature regarding retailer-retailer strategic interaction. This table is structured as follows. The first column shows the author(s). The second column states whether the research is (game) theoretical or/and empirical. It also summarises the main method used; in the case of a (game) theoretical model it shows the game and solution concept (here, NE stands for Nash Equilibrium, SPNE for Subgame Perfect Nash Equilibrium and BNE for Bayesian Nash Equilibrium). In the case of an empirical research, the second column states what kind of model, analysis or experiment is used or conducted. The third column states the number of players in the model. That is, what does the market look like in the model? How many retailers and how many customers are there? In case the researchers researched more than one model, the players in the other models are indicated as well. The models are given a number: model 1 is discussed first in the research, and model 2 second. The fourth column states whether PWYW, NYOP and/or PP are the main subjects of the research. Here, PWYW stands for 'pay-what-you-want', NYOP stands for 'name-your-own-price' and PP stands for 'posted pricing'. The fifth column states the most important assumptions made in the research regarding customer behaviour. The final column summarises the main conclusions from the research in one or two sentences.

In Table 2 the literature regarding retailer-customer strategic relations is given. The table is structured in the same way as Table 1. However, there is an additional column: 'Multiple bidding'. This column indicates whether the set-up of the research allow customers to place multiple bids.

Table 1: Overview of literature on retailer-retailer interaction

Authors	Method & solution concept	Players in the model	Pricing strategy used	Assumptions on customer behaviour	Main conclusion
Chen et al., 2014	**Theory:** ultimatum game, SPNE	**Model 1:** 2 service providers, 1 retailer and customers **Model 2:** 2 service providers, 2 retailers and customers	NYOP compared to PP	Customers are forward-looking.	Posted pricing dominates NYOP in competition; the dominance disappears if there is no competition for a service provider. Retailers prefer the posted pricing strategy.
Fay, 2009	**Theory:** duopoly model, SPNE	2 retailers and customers	NYOP compared to PP	Customers maximise expected value.	NYOP soften price competition.
Krämer et al., 2015	**Theory:** monopoly and duopoly model, SPNE and BNE **Empirics:** controlled laboratory experiment	**Model 1:** 1 retailer and customers **Model 2:** 2 retailers and customers	PWYW & NYOP compared to PP	Customers are fully rational and purely self-interested.	NYOP relaxes price competition.
Samahita, 2015	**Theory:** monopoly and duopoly model, NE and SPNE	**Model 1:** 1 retailer and customers **Model 2:** 2 retailers and customers	PWYW compared to PP	Customers maximise their net surplus.	PWYW can avoid competition on price.

Table 2: Overview of literature on retailer-customer interaction

Authors	Method & solution concept	Players in the model	Pricing strategy used	Assumptions on customer behaviour	Multiple bidding	Main conclusion
Chen, 2012	**Theory:** dynamic model, BNE	1 customer more than 2 retailers	NYOP	Customers maximise payoff.	Yes	Optimal bidding strategy could have a convex shape (price ceiling equilibrium: pooled, not efficient; fully screening equilibrium: separating, efficient).
Fay, 2004	**Theory:** static model, NE	1 retailer and 1 customer	NYOP and PP	Customers are rational and utility maximising buyers.	Yes & No	Posted pricing weakly dominates NYOP.
Han & Terwiesch, 2003	**Theory:** dynamic choice model **Empirics:** dynamic choice model	1 retailer and 1 customer	NYOP	Customers are utility maximising buyers.	Yes & No	Optimal bidding behaviour depends on customer's subjective distribution of the threshold price, customer' reservation price and friction cost.
Hinz, 2007	**Theory:** bargaining game with agent-based simulation, NE	50 retailers and 1000 customers	NYOP	Customers maximise utility, are risk-neutral and have common knowledge	No	NYOP is more suitable for a market with a high uncertainty about costs of the retailer.
Spann et al., 2004	**Theory:** closed form solutions **Empirics:** closed form solutions and an algorithm	1 retailer and 1 customer	NYOP	Customers are risk neutral and maximise expected utility.	Yes & No	Sellers should allow multiple bidding in NYOP markets; customer updates his beliefs about the threshold.
Spann & Tellis, 2006	**Theory:** model from Spann et al., 2004 **Empirics:** regression analysis	1 retailer and 1 customer	NYOP	Customers maximise expected surplus.	Yes	Optimal bidding strategies depend on the successfulness of bids, which lead to different shapes of bid functions. Customers are not strictly rational.
Terwiesch et al., 2005	**Theory:** bargaining equilibrium model **Empirics:** stochastic dynamic programming formulation	1 retailer and 1 customer	NYOP and PP	Customers are risk neutral.	Yes	By using rebid NYOP the customer cannot commit, and when the bid is rejected (although above threshold), the customer will likely bid again higher (giving retailer a higher profit).
Voigt & Hinz, 2014	**Theory:** Nash Game, NE **Empirics:** laboratory experiment	**Model 1**: 1 retailer and 1 customer **Model 2**: 20 retailers and 80 customers	NYOP	Customers maximise payoff and have rational bidding behaviour.	Yes	Due to risk averseness of the customers, NYOP is sustainable in the long run. Customers place medium bids, while retailers set thresholds close to marginal costs.

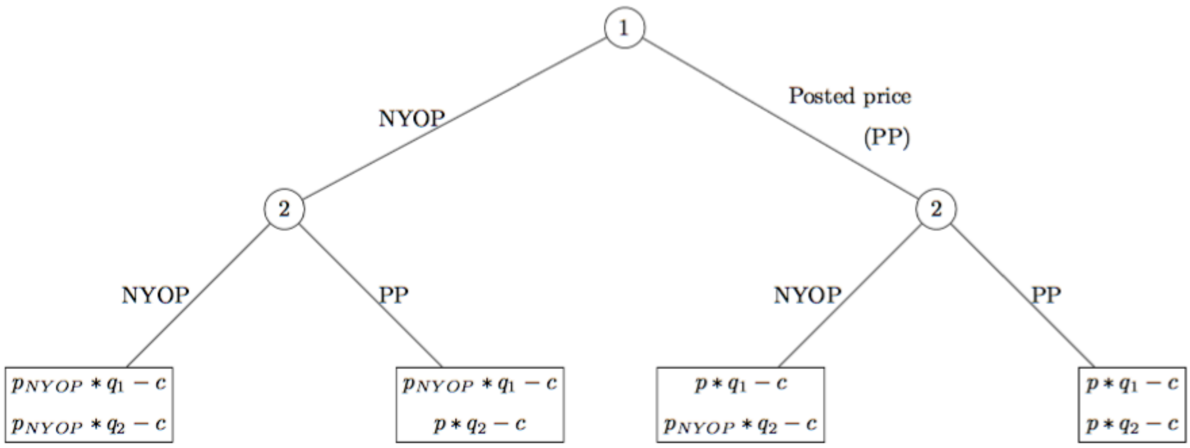
Section 3. Theoretic framework

This section explains the game theoretic model that is used to answer the research question.

3.1 The game setting

To answer the research question a dynamic game, with two periods as seen in Tadelis (2013), is used. As the game has two stages over a discrete time horizon, this game is called a discrete-time game (Başar, 2014). The game has three players: two retailers and customers in general. The game starts with the retailers adopting a certain pricing strategy: a posted or NYOP pricing strategy. After the pricing strategies are chosen, the customers observe these strategies and choose where to buy the product. Thereafter, the profits of the retailers are realised. As this is a dynamic game, the game is solved with backward induction (Frank, 2010; Tadelis, 2013). To help understand the concept and to build the model, the game is first evaluated for a single retailer. Therefore, a monopoly model is built in section 4. In section 5, the game is extended to two retailers. This duopoly game as depicted in figure 1 is solved in section 5.

Figure 1: Extensive form of the game



3.2 Actions of the retailers and customers

Both retailers have two choices in the game: they either adopt a posted pricing strategy or a NYOP pricing strategy. As this game is based on game theory, both players choose what is best for them while taking into account the possible actions of their competitor.

The profit of the retailer depends on the behaviour of the customer. When the retailer uses posted prices, he sets a price that is equal for all customers. When the retailer has set the posted price, every customer that has a lower valuation for the product does not buy the product. Every customer that has an equal or higher valuation for the product buys the product and earns a surplus of the difference between the customer's valuation and the price paid. The customer that has the same valuation for the product as the price earns a surplus of zero.

When the retailer chooses a NYOP pricing strategy, the retailer does not state a posted price. The customer has to fill out the price on the website of the retailer, which the retailer accepts or not. The customer will likely place a bid that is lower than his valuation, such that the customer gains a surplus. By using a NYOP pricing strategy, the customer has to name a price first, revealing some information about his valuation for the product. Therefore, there is a risk: if the customer names a price below the threshold, his bid is not accepted and he cannot buy the product. Here lies a trade-off for the customer; he wants the product but also want to gain as much surplus as possible.

3.3 The assumptions

Following Tadelis (2013), we make the following assumptions in order to solve the game:

1. All players are rational. This means that retailers optimise their profits and customers optimise their utility, while taking into account all costs, benefits and risks.
2. Both retailers have identical costs.
3. Retailers cannot collude. That is, retailers cannot make pricing agreements to get a higher price than the market price.
4. Both retailers sell the same, homogeneous product.

In contrast to Fay (2009), we make the following assumption in order to simplify the model:

5. Customers do not have a preference for a certain retailer.

Section 4. The monopoly model

4.1 The monopolist with a posted pricing strategy

In this section, the model for a monopolist with posted prices is constructed. The price for the monopolist is defined as follows:

$$P = a + bq \tag{1}$$

Here, a is the price when the retailer produces no quantity. b captures the price elasticity. Price elasticity determines how much a change in the price results in a change in the quantity. A higher price elasticity indicates that a price change has a large effect on the demand, which results in a steeper demand curve. Note that b is a negative number since the relation between price and quantity is negative.

The revenue (R) of the monopolist is equal to the price (P) times the quantity (q):

$$R = P \times q = aq + bq^2 \quad (2)$$

The marginal revenue (MR) of the monopolist is equal to:

$$MR = \frac{\partial R}{\partial q} = a + 2bq \quad (3)$$

The total costs of the monopolist are defined as:

$$TC = wq \quad (4)$$

where w are the variable costs.

The marginal costs (MC) of the retailer are equal to:

$$MC = \frac{dTC}{dq} = w \quad (5)$$

The monopolist maximises his profits when the marginal revenue is set equal to the marginal costs (Frank, 2010).

$$MR = MC \quad (6)$$

$$a + 2bq = w \quad (7)$$

When solving this equality, the following equilibrium quantity is obtained:

$$q_{pp}^* = \frac{w - a}{2b} \quad (8)$$

When this equilibrium quantity is substituted in the demand function, the equilibrium price under posted pricing is equal to:

$$p_{pp}^* = \frac{1}{2}(a + w) \quad (9)$$

When the equilibrium quantity and price are substituted in the revenue and total costs function, the profit of the monopolist is equal to:

$$Monopoly\ Profit_{pp} = R - TC \quad (10)$$

$$= \left(\underbrace{\frac{1}{2}(a + w) \times \left(\frac{w - a}{2b}\right)}_{R = p \times q} \right) - \underbrace{w\left(\frac{w - a}{2b}\right)}_{TC} \quad (11)$$

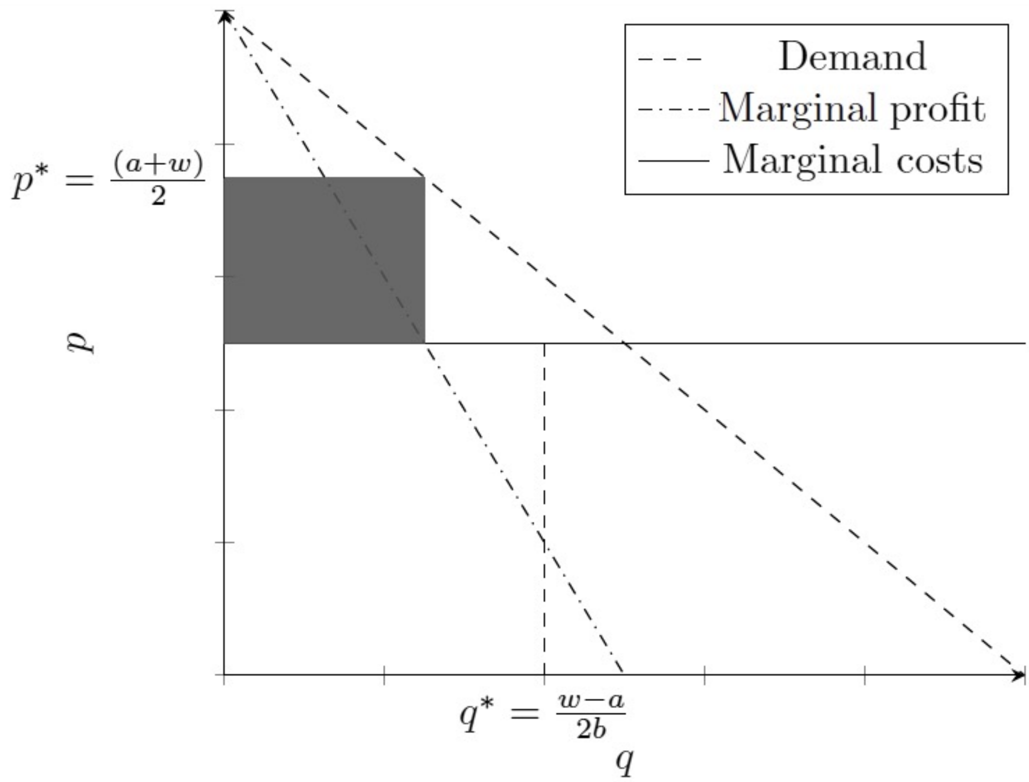
As the profit is equal to a square (see figure 2), the profit can also be calculated as:

$$Monopoly\ Profit_{PP} = \left(\frac{1}{2}(a+w) - w\right)\left(\frac{w-a}{2b}\right) = 0 \tag{12}$$

$$= -\left(\frac{(w-a)^2}{4b}\right) \tag{13}$$

The profit of the monopolist is positive as $b < 0$. Figure 2 shows the profit of the monopolist that uses posted pricing.

Figure 2: The profit of the monopolist with a posted pricing strategy



The grey area represents the profit. The triangle that is formed above the grey area, under the demand curve, is the total customers surplus (Frank, 2010).

4.2 The monopolist with a NYOP pricing strategy

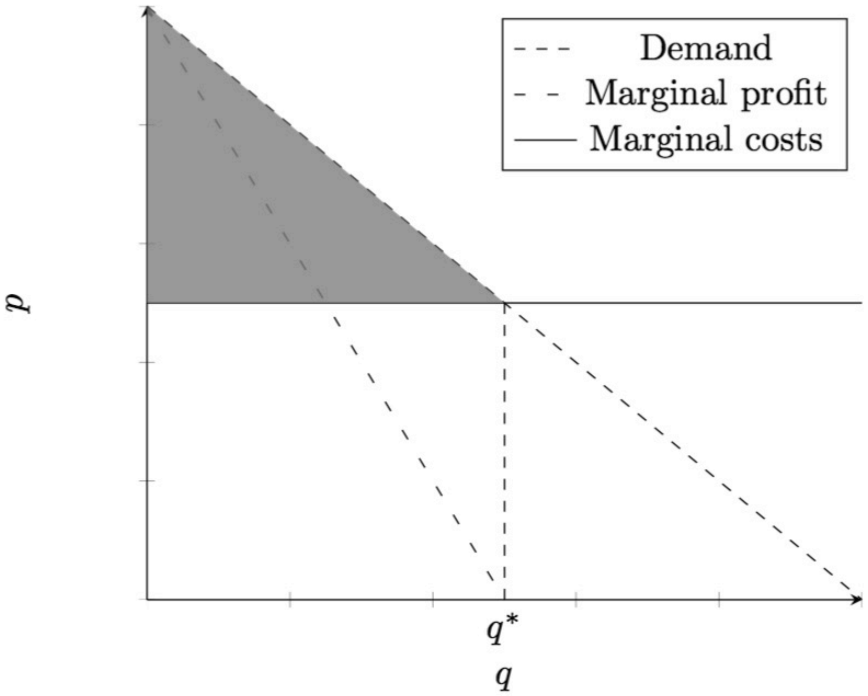
When the monopolist uses a NYOP pricing strategy, the price is equal to the bid of the customer. What is the optimal threshold for the monopolist? It is optimal for the monopolist to set the threshold equal to the marginal costs. This is because of the following reasons. Firstly, if the monopolist would set the threshold below the marginal costs, he would accept bids that would result in a marginal loss. Secondly, if the monopolist sets the threshold higher than the marginal costs, he rejects bids that would have resulted in a profit. Thus, the monopolist obtains the highest profit when he sets the threshold equal to the marginal costs.

The customer does not know the threshold. However, the customer knows that their bid has to exceed the threshold in order to win the product. If the bid exceeds the threshold, the bid is accepted and the product is sold. If the bid does not exceed the threshold, the bid is rejected and the customer cannot buy the product. As the game has a dynamic game setting, the game is solved using backward induction (Frank, 2010). As the decision of the retailer depends on the bidding behaviour of the customer, we first model the behaviour of the customer.

4.2.1 The bidding behaviour of customers

If the customer bases its bid on his true valuation, the monopolist obtains the profit equal to the grey area shown in figure 3. The demand function shows how much the customer bids for the product. When comparing figure 2 and 3 it can be noticed that in the case where the customers bid their true valuation, the NYOP pricing strategy is more profitable than the posted pricing strategy (as the grey area that represents the profit, is bigger in figure 3 than the square in figure 2).

Figure 3: The profit of the monopolist with a NYOP strategy where the customer bids their true valuation



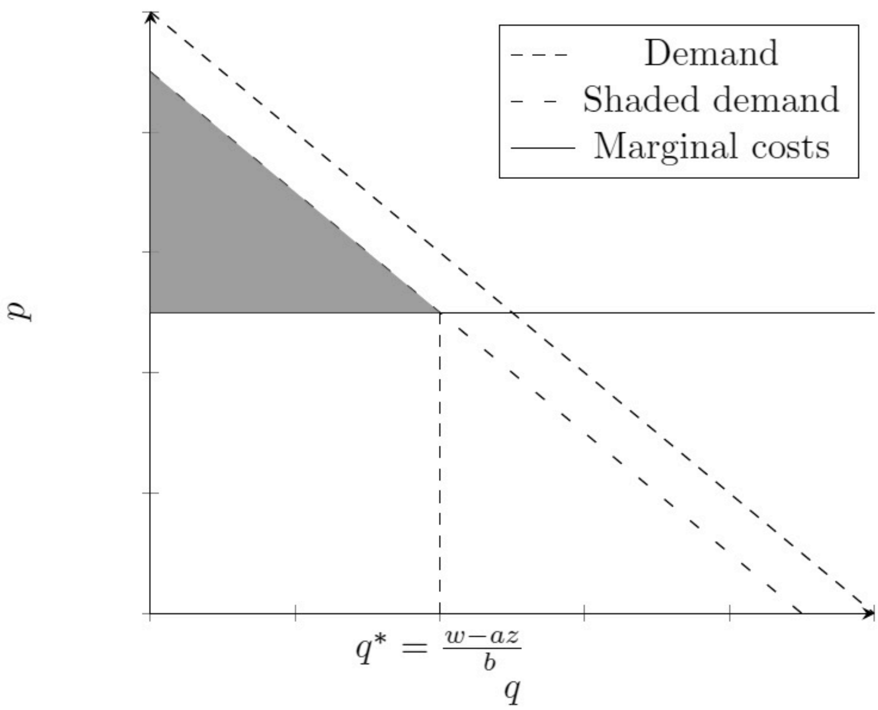
However, it is not realistic to assume that the customer bids his true valuation. The customer also uses common knowledge to determine their bid (Tadelis, 2013). This knowledge consists of his own valuation and type (such as his risk profile), but also on the information obtained through the Internet, prices of competitors or previously obtained knowledge. The customer tries to guess the true value of the threshold, as the customer can obtain the largest surplus if he sets his bid equal to the threshold set by the retailer. In other words, the customer has a dilemma. He could bid his true valuation and not gain a surplus or he could decrease his bid below his valuation in order to increase his surplus but in that case, he has a lower probability to get the product. As the customer is rational he does not make a bid that exceeds his valuation as this results in a negative surplus.

The worst-case scenario for the retailer would be that all customers would reduce their bid drastically. In that case, the NYOP pricing strategy would be less attractive than the post pricing strategy, as the NYOP strategy would result in a lower profit. The grey area in figure 3 would become smaller, as the demand curve is shifted parallely inward due to the lower bids. When the grey area becomes smaller than the square in figure 2, NYOP is less attractive than the posted pricing strategy. To make a restrictive estimation, the case where the customers will downgrade their bid is modelled. The proportion of down shading is the same for each customer. This movement and the new profit of the monopolist are shown in figure 4. As it is no longer that case that the customer bids his true valuation ($s(v) = v$), the new bidding function is written as:

$$s(v) = zv \tag{14}$$

where $s(v)$ is the bidding strategy of the customers. This behaviour consists of the true valuation of the customer (v) and the amount of down shading (z).

Figure 4: The profit of the monopolist with a NYOP pricing strategy where the customer bids less than their true valuation



To model the bidding behaviour of the customer, the first-price auction model of Easley and Kleinberg (2010) is extended.

A first-price auction is an auction where two bidders place a bid. The bidder with the highest bid wins the product. In our setting, the customer is bidding against the monopolist. The monopolist always bids the threshold for its own product, if the bid set by the customer is lower than this threshold, the monopolist 'wins' the product, and the product is not sold. If the customer bids higher than the threshold, the customer buys the product.

Easley and Kleinberg (2010) show that bidding your true value is not a dominant strategy for the customer, as the bid the customer places is equal to the amount the customer pays. Therefore, the customer gains zero surplus: the costs (the bid) are equal to the benefits (valuation for the product). If the customer shades his bid slightly downward he gets lower costs and a higher surplus. This 'shading' has two opposing forces for the customer: (1) shading the bid downward results in higher surplus for the customer, as the costs of the product are lower; (2) but when the bid is lower, the probability that the monopolist does not accept the bid increases.

There are two important assumptions regarding the customer behaviour:

1. The bidding function is strictly increasing and differentiable. Therefore, if a bidder has a higher valuation, this results in a higher bid. This excludes some possible equilibria, but it makes the analysis easier (Easley & Kleinberg, 2010).
2. Bidders can shade their bid downwards with $z < 1$. They never bid more than their true valuation; which is not optimal for the customer as it results in a negative surplus. Furthermore, the bid is always positive (Easley & Kleinberg, 2010).

Easley and Kleinberg (2010) assume that the bidding behaviour of customers follows a uniform distribution. This distribution implies that there is a fixed number of customers for each valuation of a product. That is, it is not possible that a small group has a low valuation, a larger group has an average valuation, and a smaller group has a high valuation; with a uniform distribution, each group is of equal size, or rather, for each valuation, the probability of occurring within the group is exactly the same. Research suggests however, that different groups of products have different valuations or utility distributions (Frank, 2010). Therefore, we assume that the bidding behaviour follows a non-uniform (i.e. non-linear), continuous distribution. This implies that for any valuation of a customer for a product, there is a corresponding bid.

Assume that $f(x)$ is the distribution function of the bidders' valuation. The probability that individual i outbids another bidder in the auction is $F(x)$. n is the number of bidders. The expected payoff of the customer is equal to the probability that he bids higher than the threshold, $F(v_i)^{n-1}$, times the payoff he gets from the product, $v_i - s(v_i)$. If the customer's bid is lower than the threshold, he cannot buy the product and does not have costs or a surplus. Therefore, the expected payoff of bid v_i equals:

$$E(v_i) = F(v_i)^{n-1}\big(v_i - s(v_i)\big) \tag{15}$$

A customer places a bid when his own expected payoff is higher than the expected payoff of any other bidding strategy. This can be interpreted as that he bids as if he is a customer with a lower valuation. Thus, the participation constraint is:

$$F(v_i)^{n-1}\big(v_i - s(v_i)\big) \geq F(v)^{n-1}\big(v_i - s(v)\big) \qquad (16)^1$$

for all v between 0 and 1. Now, we are going to find a bidding function that fits the condition stated above. Because we have imposed conditions on the bidding function

[1] The derivation for equation (16) to (17) can be found in Appendix A.

and its derivative, rewriting this problem into an Ordinary Differential Equation allows us to solve it. Therefore, the differential equation is:

$$s'(v_i) = (n-1)\left(\frac{f(v_i)v_i - f(v_i)s(v_i)}{F(v_i)}\right) \tag{17}$$

Using this result, we can now solve the problem for each customer valuation distribution function. We use a polynomial distribution function to define the bidding behaviour of customers and finally come to an optimal bidding strategy:

$$f(v_i) = v_i^r \tag{18}$$

$$F(v_i) = \frac{1}{1+r}{v_i}^{r+1} \tag{19}$$

such that for $r = 2$, the distribution function would be $f(x) = x^2$. By using this type of distribution function, the model can manage different types of markets. In markets with a relatively high proportion of customers with a low valuation, this can be modelled by using a lower r. In markets where people have a high valuation of the product, this can be accounted for by increasing r. This situation in which a higher r should be used, is, for example, the case when a retailer operates in a luxury market. In a luxury market, people tend to have a higher valuation for products in general. This higher valuation comes from the different aspect the luxury product holds, such as the desire to impress other people (Godey, 2013).

Another case that fits this distribution is in markets where price elasticity is low (Hausman, 1996), i.e. a market in which people respond relatively little to price changes, for example, the market for pharmaceuticals (Tellis, 1988). Furthermore, loyal buyers are less price sensitive in relation to the products of a retailer (Krishnamurthi & Raj, 1991). This also indicates that luxury brands, which have relatively more loyal buyers, have customers that are less price sensitive (Shukla et al., 2016). Finally, empirical research indicates that price elasticities are lower at the end of the product life cycle, i.e. the mature and decline stage (Bijmolt et al., 2005).

Plugging in $f(v_i)$ and $F(v_i)$, equation (18) and (19), into the differential equation (17) we get:

$$s'(v_i) = (n-1)\left(\frac{v_i^r\big(v_i - s(v_i)\big)}{\frac{1}{1+r}\ {v_i}^{r+1}}\right) \tag{20}$$[2]

As this is an equality with both a function and its derivative, we solve this Ordinary Differential Equation by finding a function that fits this equality. The solution is:

$$s(v_i) = \ c_1 {v_i}^{-(n-1)(r+1)} + \frac{nv_i}{nr+n-r} + \frac{nrv_i}{nr+n-r} - \frac{rv_i}{nr+n-r} - \frac{v_i}{nr+n-r} \tag{21}$$

$$= c_1 {v_i}^{-(n-1)(r+1)} + \frac{n+nr-r-1}{nr+n-r}\ v_i \tag{22}$$

When the customer has a valuation of zero, he would not make a bid higher than zero as this results in a negative utility. Thus, the corresponding bid is zero. Therefore:

$$s(0) = c_1 0^{-(n-1)(r+1)} + 0 \cdot \frac{n+nr-r-1}{nr+n-r} \tag{23}$$

$$s(0) = c_1 = 0 \tag{24}$$

We can use this logic to calculate that the optimal bidding function equals:

$$s(v_i) = \frac{n+nr-r-1}{nr+n-r} v_i \tag{25}$$

As there are only two bidders, the customer and the monopolist, n equals 2. So, in our case, the bidding function equals:

$$s(v_i) = \frac{2+2r-r-1}{2r+2-r} v_i = \frac{r+1}{r+2} v_i \tag{26}$$

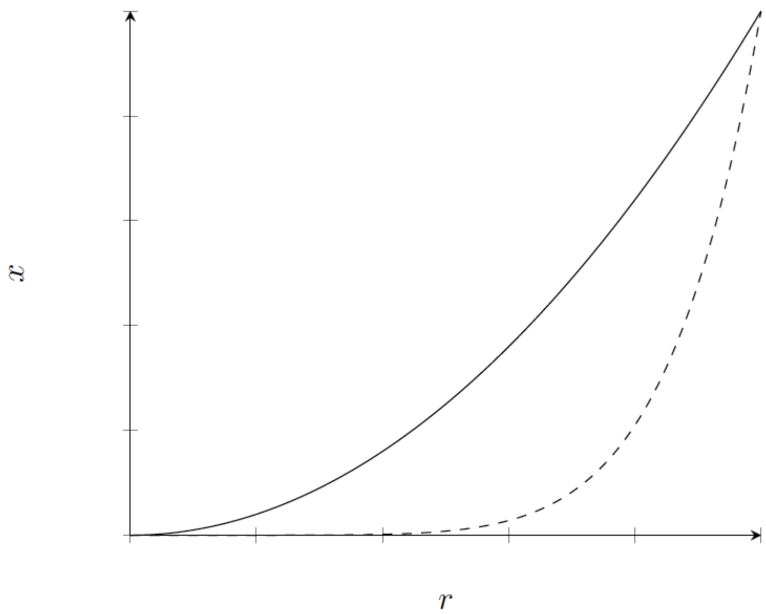
The customer shades down their bid with a factor:

$$z = \frac{r+1}{r+2} \tag{27}$$

[2] The derivation for equation (20) to (22) can be found in Appendix B.

When r is relatively low, there are more customers in the lower part of the distribution, in figure 5 this distribution is represented by the solid line. A customer can shade down his bid more, as there is a smaller chance that someone has a higher valuation above him. However, when r is relatively high, fewer customers are in the lower part of the distribution and more are in the higher end; this distribution is depicted by the dashed line in figure 5. Therefore, as the probability that another customer has a higher valuation increases, the customer can shade his bid down less, as the probability that they lose is higher.

Figure 5: Different distribution functions of customer valuations



When comparing different markets, such as a luxury market with a market for groceries, the result above has the following implications: in a market with a higher proportion of customers with a high valuation (i.e. a higher r), any random bid has a larger probability to be surpassed by another customer than in a market where more customers have a low valuation. In the market for luxury products, the customer needs to take this into account when he decides to shade his bid down. Therefore, in the luxury market, the customer shades his bid down less, while in the market for groceries; the probability the customer is outbid is smaller. Hence, the customer in the grocery market has more room to shade his bid down. This implies that in luxury markets, the employment of a NYOP strategy is automatically more profitable compared to the market for groceries, as the grocery store loses more of its profit due to people heavily shading down their bids.

The same goes for markets where the prices elasticity is low: as people are less price sensitive, they will shade their bid down less. This is the case in three situations. Firstly, in markets where the price elasticity is low in general, such as the market for pharmaceuticals (Tellis, 1988). Secondly, loyal buyers are also less price sensitive (Shukla et al., 2016). Thirdly, price elasticities are lower at the end of the product lifecycle (Bijmolt et al., 2005).

4.2.2 The profit of a monopolist with a NYOP pricing strategy

We now know how much the customer shades down his bid; therefore, we can turn to the profit of the monopolist. The customer shades his bid downward with the factor calculated above (equation (27)); this results in an inwards shift of the demand curve with z. Thus, the demand function is shaded inward linearly and becomes:

$$P = az + bq \tag{28}$$

The total costs of the monopolist are defined as:

$$TC = wq \tag{4}$$

where w is the variable cost.

The marginal costs (MC) of the retailer are equal to:

$$MC = \frac{\partial TC}{\partial q} = w \tag{5}$$

As figure 4 shows, the monopolist can perfectly price discriminate, although the demand curve is shifted inward. The bids of the customers are their true valuation minus the amount the customer down shades his bid. To obtain the whole (customer) surplus, the monopolist sets his threshold equal to the marginal costs, thus equal to w.

The equilibrium quantity is equal to:

$$q^* = \frac{w - az}{b} \tag{29}$$

The profit of the monopolist is equal to:

$$\int_0^{\frac{w-az}{b}} (az + bq - w)dq \tag{30}$$

The profit of the monopolist is equal to the revenue minus the total costs. The profit is equal to the grey triangle depicted in figure 4 and can be calculated by:

$$Profit\ NYOP\ monopolist = \frac{1}{2}(az - w) * \frac{w - az}{b} \tag{31}$$

$$= -\frac{(az - w)^2}{2b} \tag{32}$$

4.3 A posted or NYOP pricing strategy in a monopoly market?

The answer to the question whether a monopolist can better use a posted pricing or NYOP pricing scheme depends on how much the customers shade their bid down. Therefore, we now calculate how much the customer can shade their bid down until the NYOP pricing strategy becomes equally or less profitable than the posted pricing strategy.

$$Profit\ NYOP\ monopolist - Profit\ PP\ monopolist > 0 \qquad (33)[3]$$

$$-\frac{(az - w)^2}{2b} + \frac{(w - a)^2}{4b} > 0 \tag{34}$$

This holds when:

$$a > 0 \tag{35}$$

$$b < 0 \tag{36}$$

[3] The derivation for equation (33) to (38) can be found in Appendix C.

$$w < a \tag{37}$$

$$\frac{\sqrt{2}\,a - \sqrt{2}\,w + 2w}{2a} < z < \frac{-\sqrt{2}\,a + \sqrt{2}\,w + 2w}{2a} \tag{38}$$

Based on these results, NYOP is more profitable for the monopolist when these four conditions hold. As we have assumed the first three to be true, only the fourth one is of our concern. In short, whenever the marginal costs (w), the range for down shading where NYOP is still more profitable becomes narrower. In other words, in a market with higher marginal costs, the monopolist can only afford smaller down shading. This is the case in markets where more people are in the higher part of the distribution function. This is the case for markets with luxury products. To determine the precise valuation distribution of customers empirical research should be undertaken.

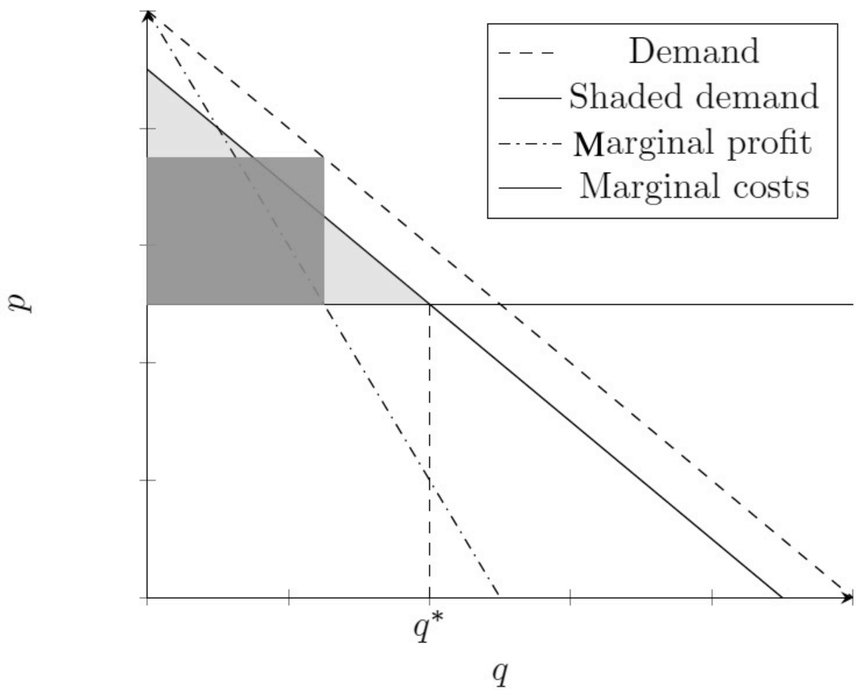
In figure 6 the effect of w on z and the profitability of NYOP is shown. The dark grey square shows the profit of the monopolist under posted pricing. The light grey triangle shows the profit of the monopolist under NYOP pricing. Figure 6 shows, just as equation (14), that the customer shades his bid down less when z is higher. The NYOP strategy becomes more profitable, as the posted pricing strategy is not influenced by z.

From the analysis above it can be concluded that a monopolist may increase profits by switching to a NYOP strategy if:

- The marginal costs are low. The lower the marginal costs, the higher the profit for the monopoly retailer when he uses a NYOP pricing strategy, as the profits are equal to the bid of the customer minus the marginal costs. Retailers that operate in an online environment usually have lower marginal costs compared to brick-and-mortar retailers (Rifkin, 2014). Therefore, a NYOP strategy is more profitable for an online retailer compared to a brick-and-mortar retailer.

- Customers shade their bid down less. If customers shade down their bid less, the marginal profit for the monopoly retailer that uses a NYOP pricing strategy is higher. NYOP could be particularly interesting for retailer in two situations. Firstly, for retailers in markets where the valuation of products is generally higher and customer shade their bid down less, such as the luxury market. Secondly, in situations where the price elasticity of customers is low, for example in specific markets with low price elasticity, in the case of loyal customers or in case when the product is at the end of his product life cycle.

Figure 6: Comparison of monopoly profit under a posted and NYOP pricing strategy



Section 5. The Bertrand duopoly model

In this section, the monopoly model is extended to a Bertrand duopoly model. There are two retailers that could choose NYOP or posted prices as their pricing strategy. There are three possible combinations:

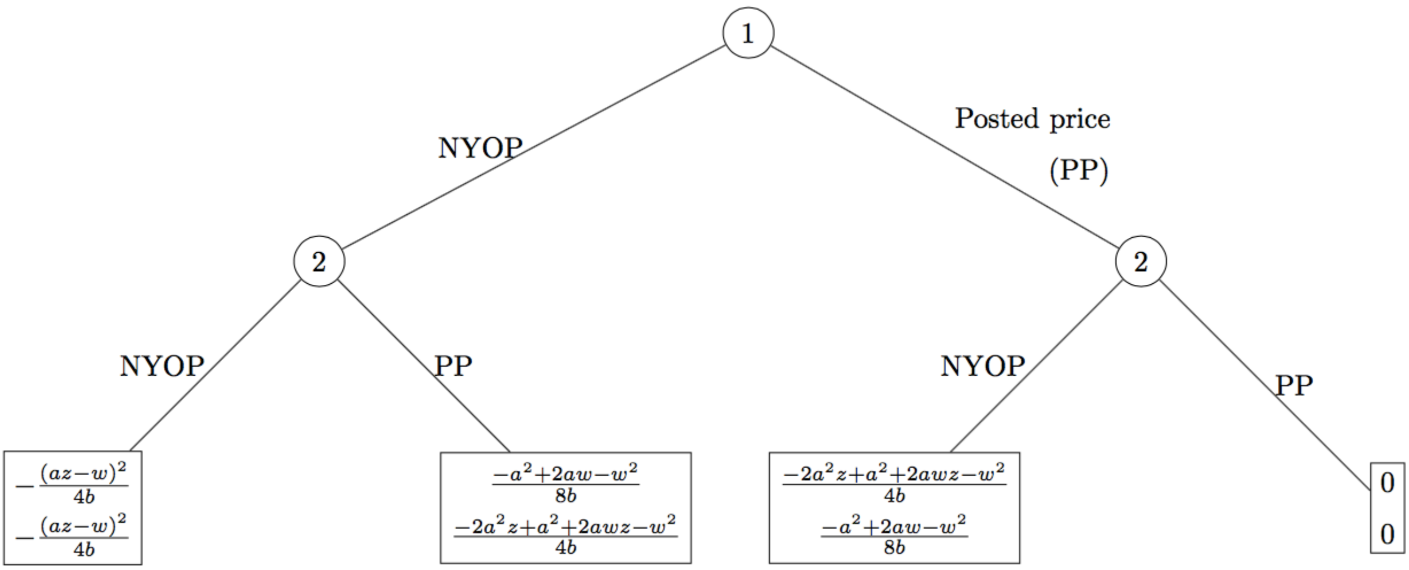
1. Both retailers choose a posted pricing strategy.

2. One retailer chooses a NYOP pricing strategy and the other retailer chooses a posted pricing strategy.
3. Both retailers choose a NYOP pricing strategy.

For each of the three combinations, the profit of both retailers is discussed in a separate paragraph. At the end of this section the equilibrium of the game is determined.

In figure 7 the extensive form of the Bertrand game is given. The profits, or payoffs, are discussed from left to right.

Figure 7: Extensive form of a price competition duopoly game



5.1 Both retailers choose a NYOP pricing strategy

If both retailers choose NYOP as their pricing strategy they would, as the monopolist, set the threshold equal to the marginal costs. Under the assumptions that the customer does not know the threshold and that the customer does not have a preference for one of the retailers, both retailers would make a profit that is equal to the half of the profit of a monopolist that pursues a NYOP strategy. Because we assume that there are no transaction costs, the probability that the customer ends up at either retailer is equal to

50%. This means that the profit for one retailer in the market with price competition equals:

$$\Pi_{1,2_{Bertrand\ NYOP}} = -\frac{1}{2}\frac{(az-w)^2}{2b} = -\frac{(az-w)^2}{4b} \tag{39}$$

5.2 One retailer choses a NYOP and one retailer choses a posted pricing strategy

The combination where one retailer chooses a NYOP strategy and one retailer chooses a posted pricing strategy has two possible orders. Either (1) the first-moving retailer chooses a NYOP pricing strategy and the second-moving retailer chooses a posted pricing strategy, or (2) first-moving retailer chooses a posted pricing strategy and the second-moving retailer chooses a NYOP pricing strategy.

(1) If the first-moving retailer chooses a NYOP pricing strategy and the second-moving retailer chooses a posted pricing strategy, the second-moving retailer has to set the price. We look at either the monopoly equilibrium price or the duopoly equilibrium price. These are two extremes; setting the price higher than the monopoly price can never be more profitable, while setting the price lower than the duopoly price in a market with two retailers never yields a higher profit either.

In the duopoly market, the equilibrium price is equal to the marginal costs due to competition. The second-moving retailer chooses the equilibrium price such that he makes the most profit. If he sets the posted price equal to the monopoly equilibrium price, the profit is higher than when he sets his price equal to the duopoly price. As with the duopoly price, the second-moving retailer gains zero profits, as prices are equal to marginal costs. Therefore, when the first-moving retailer chooses a NYOP strategy, and the second-moving retailer chooses a posted pricing strategy, the posted price is equal to the monopoly equilibrium price such that the profit of the second-moving retailer is maximised. However, the customers still shade their willingness to pay down due to the possibility of bidding through the NYOP channel of the competitor. Therefore, the quantity of the posted price retailer in this case is equal to:

$$p^*_{duo_{pp}} = az + bq \tag{40}$$

$$\frac{a + w}{2} = az + bq \tag{41}$$

$$q^*_{duo_{PP}} = \frac{a + w - 2az}{2b} \tag{42}$$

The quantity of the NYOP retailer in this case is equal to:

$$az + bq = w \tag{43}$$

$$q_{PP+NYOP} = \frac{w - az}{b} \tag{44}$$

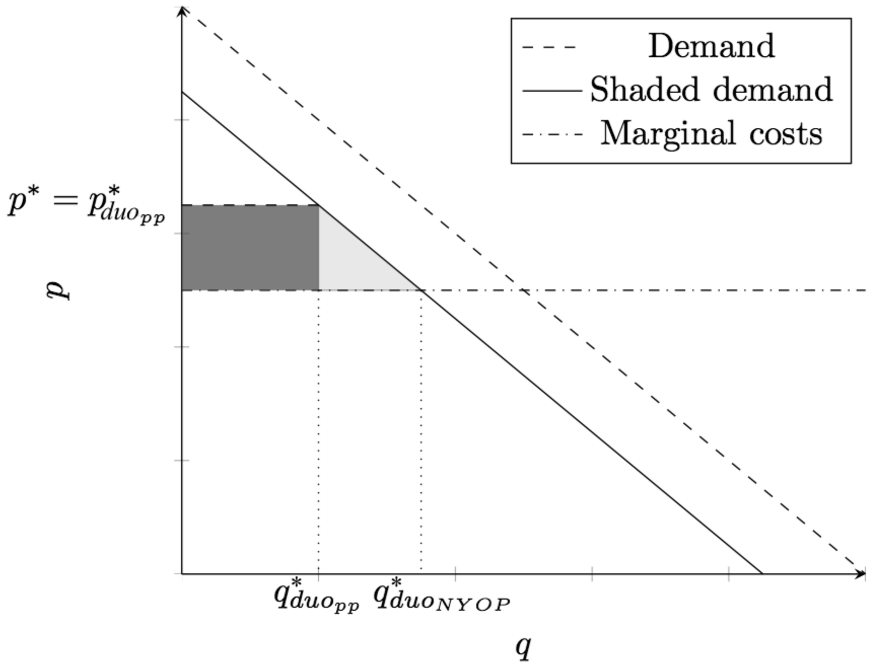
$$q^*_{duo_{NYOP}} = q_{PP+NYOP} - q_{duo_{pp}} = \frac{w - az}{b} - \frac{a + w - 2az}{2b} \tag{45}$$

$$= \frac{w - a}{2b} \tag{46}$$

As the game ends after one period, customers only have one opportunity to get the product. We assume that the customer with a higher valuation than the monopoly price buys the product from the monopolist. Therefore, this customer does not take the risk of bidding a lower price at the NYOP retailer and buys the product from the posted price retailer. There are also customers that have a higher valuation than the posted price, but due to the possibility to bid, shade their willingness to pay, under the poster price. These customers bid their shaded down bid at the NYOP retailer.

In figure 8, the profit of the posted pricing retailer is equal to the dark grey square and the profit of the NYOP retailer is equal to the light grey triangle.

Figure 8: The profits with a posted pricing strategy (dark grey) and a NYOP pricing strategy (light grey) in a duopoly market



The profit of the first-moving retailer that chooses NYOP is equal to:

$$\Pi_{duo_{NYOP}} = \frac{1}{2}\left(\frac{a+w}{2} - w\right)\left(\frac{w-az}{b} - \frac{a+w-2az}{2b}\right) \tag{47}$$

$$= \frac{-a^2 + 2aw - w^2}{8b} \tag{48}$$

The profit of the second-moving retailer that chooses posted pricing is equal to:

$$\Pi_{duo_{PP}} = \left(\frac{a+w-2az}{2b}\right)\left(\frac{a+w}{2} - w\right) \tag{49}$$

$$= \frac{-2a^2z + a^2 + 2awz - w^2}{4b} \tag{50}$$

(2) When the first-moving retailer chooses a posted pricing strategy, he has to set a price before he knows what pricing strategy the second-moving retailer chooses. The first-moving retailer could choose to set the price equal to the duopoly equilibrium price, that is, the price is equal to the marginal costs. In that case, the retailer would not have profits for sure, regardless of the choice of the second-moving retailer. If the first-moving retailer sets the price equal to the monopoly price, and the second-moving

retailer chooses NYOP, both retailers make a profit. The monopoly equilibrium price is a stable equilibrium, as the second-moving retailer is not directly competing on price with the first-moving retailer. The second-moving retailer hides its price by using the NYOP strategy. Therefore, there is no race to the bottom as in the case where both retailers choose a posted pricing strategy. The profit of the first-moving retailer that chooses posted pricing is equal to:

$$\Pi_{duo_{PP}} = \left(\frac{a + w - 2az}{2b}\right)\left(\frac{a + w}{2} - w\right) \tag{51}$$

$$= \frac{-2a^2z + a^2 + 2awz - w^2}{4b} \tag{52}$$

The profit of the second-moving retailer that chooses NYOP is equal to:

$$\Pi_{duo_{NYOP}} = \frac{1}{2}\left(\frac{a + w}{2} - w\right)\left(\frac{w - az}{b} - \frac{a + w - 2az}{2b}\right) \tag{53}$$

$$= \frac{-a^2 + 2aw - w^2}{8b} \tag{54}$$

5.3 Both retailers choose a posted pricing strategy

The last situation is where both retailer chose a posted pricing strategy. The first-moving retailer has to set his price first. However, he has to take into account that the second-moving retailer will set a price after him. It is very likely that the second-moving retailer will set his prices somewhat below the price of the first-moving retailer. The first-moving retailer has to take this into account when setting his price first. This leads to prices driven down towards the marginal costs. Therefore, the first-moving retailer will set his price equal to the marginal costs, as will the second-moving retailer. Thus, when both retailers choose posted pricing, this leads to the equilibrium where prices are equal to marginal costs.

5.4 The equilibrium

In order to find out whether the retailers use a NYOP or a posted pricing, the game is solved with backward induction. That is, we first look at what the second-moving retailer best choice is if the first-moving retailer chooses a certain set pricing strategy. We compare the two profits of the two pricing strategies for the second-moving retailer with each other. If one of the two profits is larger, the second-moving retailer always prefers this pricing strategy over the other.

The second-moving retailer compares his profits under two circumstances. Firstly, when the first-moving retailer chooses the posted pricing strategy, and second when the first-moving retailer chooses the NYOP pricing strategy. When the first-moving retailer chooses NYOP, the second-moving retailer chooses NYOP if:

$$-\frac{(az-w)^2}{4b} > \frac{-2a^2z + a^2 + 2awz - w^2}{4b} \tag{55}$$

$$-\frac{a^2z^2}{4b} > -\frac{a^2z}{2b} + \frac{a^2}{4b} \tag{56}$$

$$-a^2(z^2 - z + 1) < 0 \tag{57}$$

As – a^2 is always negative and $z^2 - z + 1$ is always positive, this inequality holds. NYOP is in this model always more profitable as:

$$a > 0 \tag{58}$$

$$b < 0 \tag{59}$$

$$z < 1 \tag{60}$$

As we have assumed that $a > 0, b < 0$ and $z < 1$, NYOP is always more profitable than posted pricing for the second-moving retailer when the first retailer chooses NYOP. As in in this model it is always the case that $z < 1$, NYOP is always more profitable than the posted pricing strategy. This implies that the retailer in a duopoly market would not even have to investigate how much the customers shade their bid down in order to make the choice to pursue a NYOP or posted pricing strategy.

When the first-moving retailer chooses posted pricing, the second-moving retailer chooses NYOP if:

$$\frac{-a^2 + 2aw - w^2}{8b} > 0 \tag{61}$$

This inequality holds when:

$$b < 0 \tag{62}$$

$$w < a \tag{63}$$

As we assumed these to be true in section 4, the inequality always holds.

So, the second-moving retailer always chooses the NYOP pricing strategy, regardless of what strategy the first-moving retailer chooses. The first-moving retailer can compare the payoffs of the second-moving retailer as well, as this is a perfect information game. Therefore, the first-moving retailer knows that the second-moving retailer always chooses the NYOP strategy. The first-moving retailer therefore compares the payoff he gets when he chooses NYOP or posted pricing, when the second-moving retailer chooses NYOP. The first-moving retailer chooses NYOP if:

$$-\frac{(az - w)^2}{4b} > \frac{-2a^2z + a^2 + 2awz - w^2}{4b} \tag{64}$$

This inequality holds when:

$$a > 0 \tag{65}$$

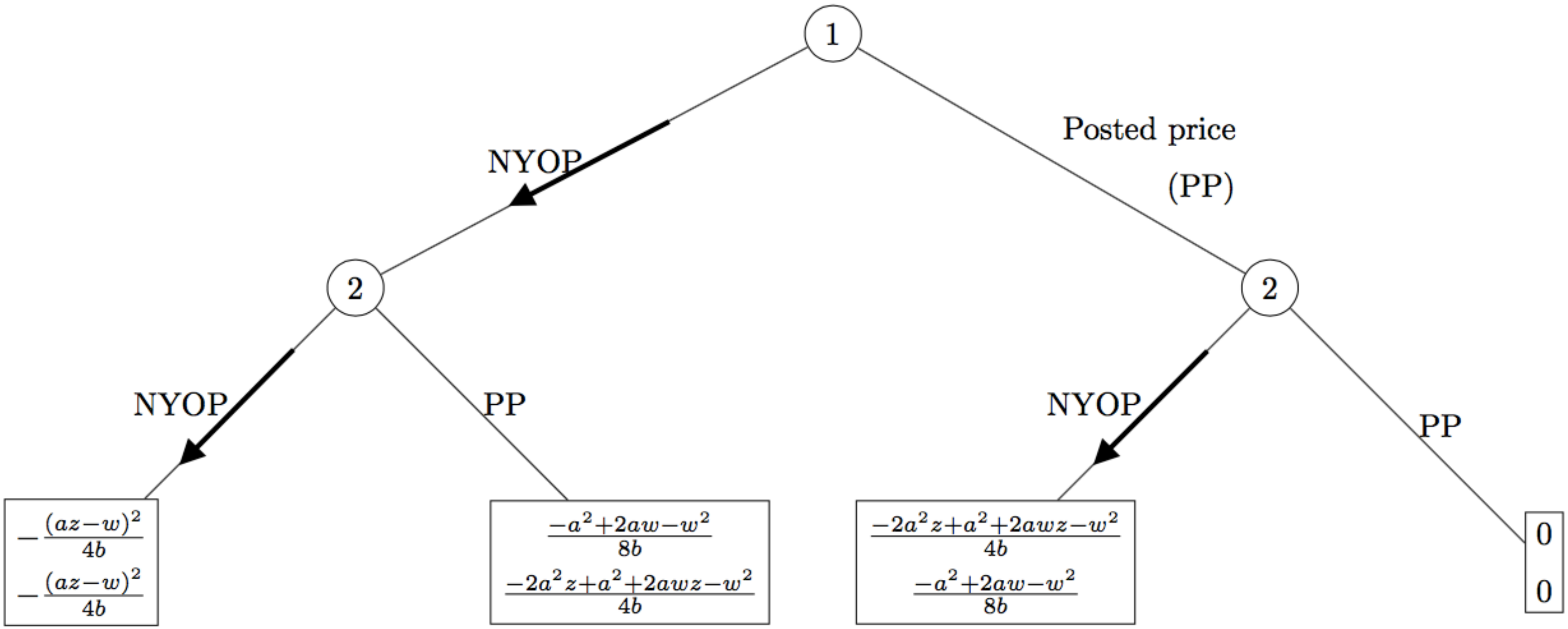
$$b < 0 \tag{66}$$

$$z < 1 \tag{67}$$

As these requirements are within the boundaries of the model, the first-moving retailer chooses the NYOP pricing strategy as well.

In this section, we found that in a duopoly market, where retailers can choose between a NYOP and posted pricing strategy, both retailers prefer to pursue a NYOP strategy. This is due to a number of reasons. Firstly, retailers can avoid price competition and the following race to the bottom resulting in zero profits. This is due to the fact that the retailers can hide their prices from each other. Therefore, both retailers cannot start a price war by stating a lower price than their competitor. Secondly, the NYOP pricing strategy gives both retailers a higher profit in general. Customers have to bid a price and will only obtain the product once the bid is higher than the threshold set by the retailer. As it is optimal for both retailers to set the threshold equal to their marginal costs, products are only sold at a profit. If both retailers would pursue a posted pricing strategy, price competition would drive profits for both retailers down to zero. Finally, as in the case of a monopolistic retailer, NYOP is more profitable for retailers in a duopoly market when the valuation of the customer for the product is higher and/or the elasticity in the market lower.

Figure 9: The equilibrium of the duopoly game where both retailers compete on price



Section 6. Experiment

This section discusses the results of an online experiment. The experiment specifically tests whether the assumptions of the theoretical model are consistent with actual human behaviour, namely the assumptions that (1) the pricing decision of the first-moving retailer does not influence the decision of the second-moving retailer and (2) expectations about the decision of the second-moving retailer do not influence the decision of the first-moving retailer. If the assumptions used in the theoretical model prove to be consistent within the experiment, the implications of this model are more substantial. If the assumptions do not hold, the experiment may give directions to improve the model in future research.

6.1 Set-up of the experiment and expectations

The experiment had the form of a survey.[4] The survey started with a general introduction about a duopoly market and the possible pricing strategies. Thereafter, the respondent played the duopoly game as developed in section 5. That is, the respondent had to choose what pricing strategy he would use if he were the first- and second-moving retailer. In this experiment, the respondent was asked to assume that he was the Head of the Marketing Department of a website that offered airline tickets and hotel stays and as such had to determine the pricing strategy in two different situations. A vignette method was used to frame the question such that it approximated a realistic situation (Watson et al., 2002). The survey was designed using the survey software of Qualtrics.

[4] The complete survey can be found in Appendix D.

After this introduction, the respondent first got one question that was related to the situation of the second-moving retailer. As in the theoretical model, the second-moving retailer can be in two situations: the first-moving retailer has either chosen a NYOP or a posted pricing strategy. This question had a between-subject design and therefore the treatment was randomly assigned to a respondent. That is, the respondent answered what pricing strategy they would choose when the first-moving retailer chose either a NYOP or a posted pricing strategy. From the theoretic model, it was expected that regardless of what the competitor chose, the respondent would choose the NYOP pricing strategy.

After this question, the respondent was placed in the situation where he would be the first-moving retailer. He then had to make a decision on his pricing strategy, knowing that a new competitor would directly enter the market after his own entrance, creating a duopoly. After a short introduction of this setting, the respondent was asked what pricing strategy he would choose and to predict what pricing strategy his competitor would employ. However, a bias can arise if we would ask these two questions in this fixed order. This is because the questions on what the respondent would do as second- and first-moving retailer are not asked in isolation. That is, the answer to the previous question about the second-moving retailer might influence the answer of the respondent on what he will do as the first-moving retailer and what he thinks his competitor will do. The order of the two questions was randomised to neutralise the bias that may arise due to question-order effects (Schuman & Presser, 1996).

After these key questions, the respondent was asked to answer a few questions regarding personal characteristics, such as gender, age and study phase. The respondent was then asked whether he has any experience in making a strategic pricing decision.

This is, for example, the case when a respondent has had specific training in business economics or marketing. It was expected that once a respondent had experience in making pricing decisions, the decision-making of that respondent may be more in line with the outcome of the theoretic model as he understands the strategic implications of the choice for one of the strategies and takes into account the possible reactions of the competitor (Honig, 2004).

Apart from these questions, the experiment also used the scale proposed by Hsee et al. (2014) to measure 'lay rationality', which is defined as the notion of using reason rather than feelings to guide decisions. Furthermore, the scale proposed by Lynch et al. (2010) was used, which measures the 'propensity to plan'; this is defined as the respondents' predisposition to implement goals and subgoals into this decision-making. It may be the case that a person that scores higher on the scale of lay rationality is more likely to make a pricing strategy decision that is in agreement with the optimal strategy found in the model. The reasoning behind this is that a rational person makes a cost-benefit analysis while taking into account all possible actions and its consequences of the competitor and chooses the option that maximises his own payoff (Frank, 2010; Tadelis, 2013). As for the propensity to plan, it may be the case that the higher a person's propensity to plan is, the more likely the person is to make a pricing strategy decision that is in agreement with the optimal strategy found in the model. This could be because a person who has a high propensity to plan might be better able to oversee the consequences of the different pricing strategies (Honig, 2004). In order to test these expectations, both variables are included in the model. Both scales consisted of six statements where the respondent had to rate his agreement on a six-point Likert scale.

6.2 The respondents

The respondents were accessed through the Internet and social media and consisted mostly of university students. Although it would be ideal to have the survey filled out by managers that make pricing strategy decisions in real life, students may also have experience in making pricing decisions. This practice of using students as key respondents is common in marketing research (Amaldoss & He, 2013; Moore et al., 2007). Therefore, a question was included that focused on the respondent experience in this area. The experience may exist of simulation games, where students have to make pricing decisions in a simulated real-world business environment (Interpretive Software, 2017). Other experience may come from courses on pricing strategies and microeconomics. Furthermore, most students at university end up in managerial positions (Researchcentrum voor Onderwijs en Arbeidsmarkt, 2013). Therefore, these university students should be capable of making pricing strategic decisions leading to reliable results.

6.3 The methodology

The main estimation results are estimated using a binary logistic regression model (Janssens et al., 2008; Field, 2009). The dependent variable in each of the estimations is the choice of the respondent between employing a NYOP or a posted pricing strategy. Two regressions are estimated: one to explain the decision of the respondent as the first-moving retailer with the expectation of the first-moving retailer on the move of the second-moving retailer, and one for the respondent as if he were the second-moving retailer with the actual decision of the first-moving retailer. Both regressions include several control variables. The variables that are collected through each question are denoted in Table 3.

Table 3: Variables logistic regression model

Question	Variable Name
A or B (treatment)	Z_1 and DecisionR1
C	ExpectationR1
D	Z_2
1	Gender
2	Age
3	Experience
4	Study Phase
5	Rationality
6	Plan

DecisionR1 is a variable indicating what treatment the respondent was exposed to. *DecisionR1* takes a value of 0 if the respondent was assigned to the treatment where the first-moving retailer chose NYOP and 1 if the first-moving retailer had chosen posted pricing. *ExpectationR1* indicates the pricing strategy the respondent, as retailer 1, thinks the second-moving retailer will make. Z_1 and Z_2 are respectively the outcome variables of the first and second binary logistic regression. That is, Z_1 denotes the response to the question what the respondent would choose when he is the second-moving retailer, while Z_2 denotes the response when the respondent is the first-moving retailer. When the respondent chose NYOP, Z takes the value of 0 and when the respondent chose posted pricing, Z takes the value of 1. The variables *Rationality* and *Plan* are derived through factor analysis; the statements used per factor can be found in Appendix E.

The experiment had a between-subject design, which implies that one respondent is subjected to one treatment (Field, 2009). This design was chosen to avoid confusion and contamination effects with regard to the choice the second-moving retailer has to make. With a between-subject design, the dropout rates and carry-over effects are lower, as the survey is shorter (Gravetter & Forzano, 2015). However, a downturn of a between-subject design is the fact that different people are appointed to different treatments. This could lead to a bias in the data when the two treatment groups are not the same (Field, 2009; Gravetter & Forzano, 2015). By assigning the treatments to the respondents randomly, this bias is eliminated.

Given the variables collected, two binominal logistic regression analyses were conducted. The first binominal logistic regression relates to the choice of the second retailer:

$$\begin{aligned} Z_1 = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 Experience + \beta_4 Studyphase \\ + \beta_5 Rationality + \beta_6 Plan + \beta_7 DecisionR1 \ + \varepsilon \end{aligned} \tag{68}$$

where Z_1 is 0 if the respondent had chosen NYOP and 1 if the respondent had chosen posted pricing. The model predicts that $DecisionR1$ should not have a significant effect on the decision of the respondent (β_7 is not significantly different from zero). That is, the model predicts that the respondent will always choose NYOP, regardless of the first-moving retailer's decision.

The second binary logistic regression indicates what the influence of the variables is on the probability that the respondent will choose either NYOP or posted pricing. The second regression is:

$$\begin{aligned} Z_2 = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 Experience + \beta_4 Studyphase + \beta_5 Rationality \\ + \beta_6 Plan + \beta_7 ExpectationR1 + \varepsilon \end{aligned} \tag{69}$$

where Z_2 is 0 if the respondent had chosen NYOP and 1 if the respondent had chosen posted pricing. Again, $ExpectationR1$ should not be significant as the theoretical model predicts that it is optimal to choose NYOP regardless of the expectation of what the second-moving retailer would choose (β_7 is not significantly different from zero).

6.4 The main estimation results

This section discusses the results of the experiment. Firstly, we discuss the data; thereafter, we look at the output of the logistic regression, robustness and reliability of the estimation.

6.4.1 Description of the data

In total, the experiment reached 153 respondents, 57 (37,25%) of which were male and 96 (62,75%) were female. The average age of the respondents was 27,11 years (SD=9,23), with 18 being the minimum age and 57 the maximum. 77 (50,33%) did not have prior experience with StratSim or other simulation games, while 76 (49,67%) of the respondents did. 44 (28,76%) of the respondents was enrolled in a bachelor's programme, 8 (5,23%) were enrolled in a pre-master's programme, 76 (49,67%) was enrolled in a master's programme, while 25 (16,34%) indicated that they were not enrolled in a university programme. The average time spent on the survey was 4.02 minutes, which is in line with the previously estimated timespan.

6.4.2 Reliability and validity

As suggested by Hoetker (2007) McFadden's pseudo-R^2 is used to provide a measurement of model fit for both models. The McFadden's pseudo-R^2 is 0.069 for the first model and 0.034 for the second model (McFadden, 1973). This indicates that the estimation power for both models is small (Hill et al., 2012). The model has been tested for multicollinearity, which was found to be absent. The sample size appears to be large enough for a reliable factor analysis (Janssens et al., 2008).

When preforming a Hosmer-Lemeshow goodness-of-fit on both models, the returned p-value is equal to 0.2670 for the first model and 0.2683 for the second model, which in both cases rejects the null hypothesis of a poor fit of the model (Janssens et al., 2008). Although this does not prove that the models are correctly specified, this is an indication that they are pointing in the right direction.

6.4.3 The Results

As mentioned in section 6.1, the respondents were asked to rate their behaviour in twelve different questions, to assess their propensity to plan and their lay rationality. These questions were based on the factor analysis conducted by Lynch et al. (2010) and Hsee et al. (2014). The result of this factor analysis is depicted in the Appendix E.

The Cronbach's alpha for the questions pertaining the propensity to plan was found to be 0.8812. Lynch et al. (2010) reported this reliability coefficient to be about 0.90, which indicates that the reliability of this factor analysis is adequate. For the rationality of the respondents Cronbach's alpha is 0.6264. Hsee et al. (2014) reported reliability coefficients between 0.80 and 0.87. This indicates that the reliability for the rationality of respondents might be less-than-optimal; as suggested by Janssens et al. (2008) the lowest two factor loadings (question 6b and 6e) were deleted. After the removal, Cronbach's Alpha increased to 0.7371, which is considered to be an acceptable reliability coefficient, and therefore rationality remains in the analysis (Nunnally, 1978).

The results of the estimation of equation (68) can be found in Table 4.

Table 4: Logistic regression for second-moving retailer

Independent variable	*Coef.*	*Std. Err.*	*z*	*P>|z|*
Intercept	1.22	1.14	1.07	0.28
Female	.11	.38	0.30	0.77
Age	-.01	.02	-0.29	0.77
No Experience	.36	.40	0.91	0.36
Study phase				
Pre-master	.16	.88	0.18	0.86
Master	-.49	.42	-1.17	0.24
Other	-.69	.57	-1.23	0.22
Rationality	.20	.22	0.95	0.34
Plan	-.31*	.17	-1.81	0.07
DecisionR1 = PP	-.97***	.35	-2.77	0.01
N	153			
Pseudo R2	0.07			
Dependent variable	Z1			
* = p < 0.10				
** = p < 0.05				
*** = p < 0.01				

The results indicate that the treatment, indicting which pricing strategy the first-moving retailer employs, actually has a significant effect on the decision of the respondent. In fact, if an average respondent was faced with a competitor that chose posted pricing instead of NYOP, he would be 23% less likely to choose posted pricing. This is also visible in the data: of the 79 respondents that were faced with a first-moving retailer that choose NYOP, 49 (62%) choose posted pricing. Of the 74 respondents that were faced with a first-moving retailer that chose posted pricing, 44 (59%) chose NYOP. It appears that the respondents might have the feeling that as their competitor is using the one strategy, it is favourable for them to choose the other strategy. The underlying assumption may be that some customers prefer the one pricing method over the other. In the theoretical model, it was assumed that this was not the case. The variable 'propensity to plan' is significant on a 10% significance level. With regard to the second-moving retailer there seems to be a significant, negative relationship between the propensity to plan of the individual and the ability to find the optimal strategy for the second-moving retailer, namely NYOP. This finding is in line with the expectation. All other variables do not have a significant effect on the decision to choose either NYOP or posted pricing on a 10% significance level.

The results of the estimation of equation (69) can be found in Table 4.

Table 5: Logistic regression for first-moving retailer

Independent variable	***Coef.***	***Std. Err.***	***z***	***P>|z|***
Intercept	-1.25	1.10	-1.13	0.26
Female	.091	.37	0.25	0.81
Age	.023	.02	1.08	0.28
No Experience	-.53	.39	-1.35	0.18
Study phase				
Pre-master	.26	.85	0.31	0.76
Master	.31	.41	0.76	0.45
Other	1.00*	.55	1.81	0.07
Rationality	.01	.21	0.03	0.98
Plan	.05	.17	0.27	0.78
ExpectationR1 = PP	.13	.34	0.38	0.71
N	153			
Pseudo R2	0.03			
Dependent variable	Z2			
* = p < 0.10				
** = p < 0.05				
*** = p < 0.01				

As theorised, the expectation of the respondent did not significantly influence the decision of the respondent. It appears that this assumption of the model does hold. The study phase 'other' is significant at a 10% level. This group consisted of only 25 respondents with a diverse background. These respondents either mentioned that they were graduated, working or had a lower education, or refused to answer the question. Therefore, it is difficult to understand why the respondents that chose 'other' are more likely to choose the posted pricing strategy. It might be that there is some unobserved confounder, though this remains unclear within this dataset. All other variables are not significant at a 10% significance level.

Section 7. Conclusion

7.1 General discussion

This thesis posted the following research question:

How are the profits of retailers influenced when they use a NYOP pricing strategy instead of a posted pricing strategy in a duopoly market, while taking into account possible strategic actions of customers?

To answer the question a theoretical model, to map the decision of a retailer confronted with the dilemma which pricing strategy to implement, was developed. Firstly, the choice of such a retailer was modelled as if he were the monopolist in the market. To model the behaviour of the customers, the model by Easley and Kleinberg (2010) was extended, to account for the bidding strategies of the customers. This model showed that it was optimal for customers to shade their bid down in a NYOP environment. Using this understanding of the bidding of the customers, the analysis showed that for markets with a high valuation for the product sold and/or markets with a low price elasticity, NYOP would lead to more profit than a posted pricing strategy. Switching to a NYOP pricing strategy would thus be more profitable for a monopolist in a market with high-valued, price inelastic products.

As few retailers are in a monopolist position, the analysis was extended to account for two retailers competing on price – a Bertrand duopoly market. To do so, the retailers were placed in a game in which one would be the first mover and the other would be the second mover. Using the insights obtained from the monopoly model, the game was solved using backwards induction. The analysis showed that in all cases, regardless of the market, both retailers would choose to employ a NYOP pricing strategy, as this would yield more profits for both retailers. The total profit earned by both retailers was shown to be larger than if both retailers would employ a posted pricing strategy.

To understand whether the conclusions drawn from the theoretical analysis were supported in an empirical setting, a small-scale experiment was conducted. This experiment showed that in fact most respondents, acting as the second-moving retailer, would choose the opposite strategy. Which is in contrary to the theoretical model, which suggests that the second-moving retailer's choice would be independent from the choice of the first-moving retailer. However, if the respondents were acting as the first-moving retailer, their expectation about the behaviour of the second-moving retailer did not influence their decision, which is in line with the theoretical model.

In theory, NYOP leads to higher profits if both retailers choose to implement NYOP. However, the experiment has shown that retailers do not always choose the NYOP pricing strategy as predicted by the theoretical model. Therefore, resulting profits are not always in line with the theoretical prediction.

7.2 Managerial implications

The NYOP pricing strategy is easiest implemented through an online system, therefore the implications of this thesis are mostly interesting for managers of online retailers that mostly compete on price, such as BestBuy.com and Walmart.com, who both offer the lowest price guarantee. This thesis yields the following implications for such retailers and recommendations for its managers.

Firstly, we found that retailers always preferred NYOP over the posted pricing strategy, as NYOP always leads to higher profits for both retailers compared to posted prices. The main implication is that the NYOP pricing strategy is more profitable for online retailers compared to the posted pricing strategy under certain requirements. For the manager of a retailer with competitors, it is recommended to investigate the main competition element of the retailer. Once the manager finds that the main element of competition is the price, it is recommended to implement the NYOP pricing strategy. For a manager of a monopolistic retailer, the NYOP pricing strategy is recommended to implement when customers do not heavily shade their bid down, when this is the case will be elaborated upon in the next paragraph.

Secondly, the theoretical model also showed that a NYOP pricing strategy is especially profitable in markets where more customers have a higher valuation for the product, which is the case in the luxury market. NYOP is also more profitable when customers are less sensitive to prices, which is, for example, the case when buyers are loyal to the retailer, or when the product is at the end of the product lifecycle. This is due to the fact that customers shade their bid down less when they value to product more or when they are less price sensitive. When the customer shades his bid down a lot, as is the case for products that are valued less, the NYOP pricing strategy quickly becomes less profitable compared to the posted pricing strategy. These findings hold for both retailers that are monopolist in the market and retailers that have a competitor. If a manager wants to implement the NYOP pricing strategy it is therefore highly recommended that he has an adequate understanding of the valuation of the customer and the price sensitivity of customers.

Finally, if the marginal costs of the product sold by the retailer are low, the profitability of the NYOP pricing strategy increases. As the profit for the retailer is equal to bid of the customer minus the marginal costs, the lower the marginal costs, the larger the profit. This holds for a monopolistic retailer and retailers that have a competitor in the market. It recommended for the manager to investigate the marginal costs in order to determine the profitability of the NYOP pricing strategy. If they are low, it is recommended to use a NYOP pricing strategy and to set the threshold equal to the marginal costs in order to obtain the maximal profit out of the NYOP pricing strategy.

7.3 Academic contributions

Thus far, the research on NYOP mainly focuses on the strategic reaction of customers on NYOP pricing schemes, but does not take the competition between retailers into account. The literature on the competitive implications of NYOP and posted pricing strategies do model customer behaviour, however, most of these papers assume that customer bid uniformly and bid their willingness to pay (Anderson & Wilson, 2011). Easley and Kleinberg (2010) state that it is not optimal for a customer to bid their willingness to pay. Instead, customer would shade their bid down in order to gain some surplus.

This thesis contributes to the literature by relaxing the assumption of uniform bidding functions. In order to do so, the model by Easley and Kleinberg (2010) on customer bidding strategies is extended. Easley and Kleinberg (2010) used a uniform distribution. As it is not realistic that every customer has the same valuation and therefore has the same bid, the model is extended to a polynomial distribution to define the bidding behaviour of customers. This distribution allows customers to have a different valuation of a product.

Furthermore, the fact that it is optimal for customers to shade their bid down, as suggested by Easley & Kleinberg (2010), is also taken into account when modelling the bidding behaviour of customers. This effect was often ignored in previous literature on price competition between retailers, as discussed in section 2.1.1. However, it is very important because the down shading of the bid results in a lower profit for the retailer when using a NYOP pricing strategy. It therefore influences the strategic decision of the retailer.

Finally, this thesis implements the polynomial bidding functions of customers and the strategic action of down shading into a duopoly game with complete information. By taking both aspects of the customers bidding behaviour, the outcome of the theoretic model is more reliable.

7.4 Limitations and future research

There are a number of limitations and suggestions for future research. With regard to the theoretical model, the assumptions made can be relaxed in future research in order to make the model more realistic.

The following assumptions related to the retailers the following assumptions could be relaxed in future research. Firstly, the assumption that both retailers have the symmetric costs is not realistic, as retailers are not identical in real life. When retailers have different marginal costs, NYOP would be more profitable for the retailer with the lower marginal costs, which may result in a different equilibrium when this assumption is relaxed. Secondly, it was assumed that customers do not have a preference for one of the retailers, i.e. that both retailers have the same reputation. However, when retailers compete mostly on prices, reputation can be a valuable asset to differentiate from the competitor, without the risk of starting a price war. It may therefore be interesting to see whether the retailers would choose a different pricing strategy if their reputation is different from each other.

The implementation of the customer behaviour can also be optimised. Firstly, the theoretical model mostly depends on the assumption that all players are rational, however, a lot of research indicates that customers are not rational (Shugan, 2006). It would therefore be interesting to see whether the conclusions of the theoretical model still hold when the assumption of rationality is relaxed, for example with the help of behavioural economics. Secondly, the bidding behaviour of the customers can be improved. In this model, customers shaded their bids down linearly. However, it is not unthinkable that some customers with certain valuations share their bid down more or less compared to other customers. This would also influence the profit of a retailer with a NYOP pricing strategy and could lead to a different conclusion whether NYOP is preferred over posted pricing. Thirdly, the theoretic model developed in this thesis only allowed customers to bid once. Spann et al. (2004) and Fay (2004) both suggest that allowing for multiple bids can increase the profit of the NYOP retailer. It would be interesting to see how customers would strategically react in this theoretic model and whether the profit of the NYOP retailer increases.

With regard to the empirical research, several limitation and suggestions can be made. The empirical research can be improved by having actual marketing managers as respondents. Although students have experience with price decision-making it would be interesting to see whether the experience of managers would make a difference in the outcome of the empirical research. The robustness of the empirical research could also be improved by increasing the number of respondents.

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Appendix

Appendix A: Equation (16)-(17)

$$F(v_i)^{n-1}\big(v_i - s(v_i)\big) \geq F(v)^{n-1}\big(v_i - s(v)\big) \tag{A1}$$

Maximise the right-hand side. Differentiate with respect to v:

$$F(v)^{n-1}v_i - F(v)^{n-1}s(v) \tag{A2}$$

$$(n-1)F(v)^{n-2}f(v)v_i - [(n-1)F(v)^{n-2}f(v)s(v) + F(v)^{n-1}s'(v)] = 0 \tag{A3}$$

Set $v = v_i$ and rewrite:

$$(n-1)F(v_i)^{n-2}f(v_i)v_i - (n-1)F(v_i)^{n-2}f(v_i)s(v_i) - F(v_i)^{n-1}s'(v_i) = 0 \tag{A4}$$

$$(n-1)F(v_i)^{n-2}f(v_i)\big(v_i - s(v_i)\big) = f(v_i)^{n-2}s'(v_i) \tag{A5}$$

$$(n-1)\frac{F(v_i)^{n-2}f(v_i)\big(v_i - s(v_i)\big)}{F(v_i)^{n-2}} = s'(v_i) \tag{A6}$$

$$s'(v_i) = (n-1)\frac{f(v_i)\big(v_i - s(v_i)\big)}{F(v_i)} \tag{A7}$$

Appendix B: Equation (20)-(22)

$$s'(v_i) = (n-1)\left(\frac{v_i^r\big(v_i - s(v_i)\big)}{\frac{1}{1+r}\;{v_i}^{r+1}}\right) \tag{A8}$$

Solve the linear equation:

$$\frac{ds(v_i)}{dv_i} = \frac{(n-1)(r+1)\big(v_i - s(v_i)\big)}{v_i} \tag{A9}$$

Rewrite the equation:

$$\frac{ds(v_i)}{dv_i} + \frac{(n-1)(r+1)s(v_i)}{v_i} = (n-1)(r+1) \tag{A10}$$

Let: $\mu(v_i) = e^{\int \frac{(n-1)(r+1)}{v_i} dv_i} = e^{(n-1)(r+1)\ln(v_i)} = v_i^{(n-1)(r+1)}$

Multiply both sides by $\mu(v_i)$:

$$v_i^{(n-1)(r+1)} \frac{ds(v_i)}{d(v_i)} + \left((n-1)(r+1){v_i}^{(n-1)(r+1)-1}\right) s(v_i) = (n-1)(r+1)v_i^{(n-1)(r+1)} \tag{A11}$$

Substitute: $(n-1)(r+1)v_i^{(n-1)(r+1)-1} = \frac{d}{dv_i}\left(v_i^{(n-1)(r+1)}\right)$

$$v_i^{(n-1)(r+1)} \frac{ds(v_i)}{dv_i} + \frac{d}{dv_i}\left(v_i^{(n-1)(r+1)}\right)s(v_i) = (n-1)(r+1)v_i^{(n-1)(r+1)} \tag{A12}$$

Apply the reverse product rule $g\frac{df}{dv_i} + f\frac{dg}{dv_i} = \frac{d}{dv_i}(fg)$ to the left-hand side:

$$\frac{d}{dv_i}\left(v_i^{(n-1)(r+1)}s(v_i)\right) = (n-1)(r+1)v_i^{(n-1)(r+1)} \tag{A13}$$

Integrate both sides with respect to v_i:

$$\int \frac{d}{dv_i}\left(v_i^{(n-1)(r+1)}s(v_i)\right) dv_i = \int (n-1)(r+1)v_i^{(n-1)(r+1)} dv_i \tag{A14}$$

Evaluate the integrals:

$$v_i^{(n-1)(r+1)}s(v_i) = \frac{(n-1)(r+1)v_i^{(n-1)(r+1)+1}}{(n-1)(r+1)+1} + c_1 \tag{A15}$$

where c_1 is an arbitrary constant.

Divide both sides by ${v_i}^{(n-1)(r+1)}$

$$s(v_i) = c_1 v_i^{-(n-1)(r+1)} + \frac{(n-1)(r+1)v_i}{(n-1)(r+1)+1} \tag{A16}$$

Rewrite as:

$$s(v_i) = c_1 {v_i}^{-(n-1)(r+1)} + \frac{n+nr-r-1}{nr+n-r} v_i \tag{A17}$$

Appendix C: Equation (33)-(38)

$$-\frac{(az-w)^2}{2b} + \frac{(w-a)^2}{4b} > 0 \tag{A18}$$

$$\frac{-2a^2z^2 + 4awz - 2w^2 + w^2 - 2aw + a^2}{4b} > 0 \tag{A19}$$

$$\frac{-2a^2z^2 + 4awz - w^2 - 2aw + a^2}{4b} > 0 \quad \text{(A20)}$$

As $b < 0$, the numerator is < 0. Therefore:

$$-2a^2z^2 + 4awz - w^2 - 2aw + a^2 < 0 \quad \text{(A21)}$$

$$-2(az - w)^2 + w^2 - 2aw + a^2 < 0 \quad \text{(A22)}$$

$$-2(az + w)^2 < -(a^2 - 2aw + w^2) \quad \text{(A23)}$$

$$-2(az - w)^2 < -(a - w)^2 \quad \text{(A24)}$$

$$(az - w)^2 > \frac{(a - w)^2}{2} \quad \text{(A25)}$$

$$az - w > \sqrt{\frac{(a - w)^2}{2}} \; or \; az - w < \sqrt{\frac{(a - w)^2}{2}} \quad \text{(A26)}$$

$$az > \frac{a - w}{\sqrt{2}} + w \; or \; az - w < \frac{a - w}{\sqrt{2}} + w \quad \text{(A27)}$$

$$z > \frac{a - w}{\sqrt{2}a} + \frac{w}{a} \; or \; z < \frac{a - w}{\sqrt{2}a} + \frac{w}{a} \quad \text{(A28)}$$

$$z > \frac{\sqrt{2}a - \sqrt{2}w + 2w}{2a} \; or \; z < \frac{\sqrt{2}a - \sqrt{2}w + 2w}{2a} \quad \text{(A29)}$$

Appendix D: Survey

Thank you for participating in this survey and for helping me graduate at the Erasmus University Rotterdam! This survey is completely anonymous. The survey lasts about 6 minutes.

Assume you are Head of the Marketing Department of a website that offers airline tickets and hotel stays. There are two possible pricing strategies that are suitable for your website:

- Posted pricing: you state a price on the website for which your customers can buy the airline ticket or hotel stay.
- Name your own price (NYOP): you let the customer bid on the airline ticket or hotel stay. You can accept or reject the bid of the customer.

In the market you operate in customers do not have a personal preference for you or your competitor. Your competitor has the same pricing strategy options as you have (i.e., he can choose either posted pricing or NYOP).

[The respondent either gets question A or B]

A. You have one competitor in the market, which offers the same product as you. Your competitor uses a NYOP pricing strategy. What pricing strategy will you use?

- ☐ NYOP
- ☐ Posted Pricing

B. You have one competitor in the market, which offers the same product as you. Your competitor uses a <u>posted</u> pricing strategy. What pricing strategy will you use?

- ☐ NYOP
- ☐ Posted Pricing

Now, assume that there is a new market opportunity. You will be the first to enter that market, however, you know that once you have entered that market a competitor will enter after you.

[The following two questions are asked in a random order]

C. Which pricing strategy do you think that <u>your competitor</u> will use?

- ☐ NYOP
- ☐ Posted Pricing

D. What pricing strategy will <u>you</u> use?

- ☐ NYOP
- ☐ Posted Pricing

1. What is your gender?
   - ☐ Male
   - ☐ Female

2. What is your age?
   - ☐ Select Age

3. In your study, did you work with StratSim or other simulation games, or followed courses on pricing strategies, marketing or microeconomics?
   - ☐ Yes
   - ☐ No
4. In what study phase are you currently enrolled?
   - ☐ Bachelor
   - ☐ Pre-master
   - ☐ Master
   - ☐ Other, namely _______

5. Please rate the extent to which you agree/disagree with the following statements (1 = strongly disagree and 6 = strongly agree).
   a. I set financial goals for the next 1-2 months for what I want to achieve with my money.
   b. I decide beforehand how my money will be used in the next 1-2 months.
   c. I actively consider the steps I need to take to stick to my budget in the next 1-2 months.
   d. I consult my budget to see how much money I have left for the next 1-2 months.
   e. I like to look at my budget for the next 1-2 months in order to get a better view of my spending in the future.

f. It makes me feel better to have my finances planned out in the next 1-2 months.

6. Please rate the extent to which you agree/disagree with the following statements (1 = strongly disagree and 6 = strongly agree).

a. When making decisions, I like to analyse financial costs and benefits and resist the influence of my feelings.
b. When choosing between two options, one of which makes me feel better and the other serves the goal I want to achieve, I choose the one that makes me feel better.
c. When making decisions, I think about what I want to achieve rather than how I feel.
d. When choosing between two options, one of which is financially superior and the other 'feels' better to me, I choose the one that is financially better.
e. When choosing between products, I rely on my gut rather than on product specifications (numbers and objective descriptions).
f. When making decisions, I focus on objective facts rather than subjective feelings.

End of Survey.
Thank you!

Appendix E: Results factor analysis

Item	Factor 1	Factor 2	Cronbach's Alpha
5a. I set financial goals for the next 1-2 months for what I want to achieve with my money.	0.7718		0.8812
5b. I decide beforehand how my money will be used in the next 1-2 months.	0.7634		
5c. I actively consider the steps I need to take to stick to my budget in the next 1-2 months.	0.788		
5d. I consult my budget to see how much money I have left for the next 1-2 months.	0.7192		
5e. I like to look at my budget for the next 1-2 months in order to get a better view of my spending in the future.	0.709		
5f. It makes me feel better to have my finances planned out in the next 1-2 months.	0.7071		
6a. When making decisions, I like to analyse financial costs and benefits and resist the influence of my feelings.		0.5525	0.6264
6b. When choosing between two options, one of which makes me feel better and the other serves the goal I want to achieve, I choose the one that makes me feel better.		0.2655	
6c. When making decisions, I think about what I want to achieve rather than how I feel.		0.6711	
6d. When choosing between two options, one of which is financially superior and the other 'feels' better to me, I choose the one that is financially better.		0.6413	
6e. When choosing between products, I rely on my gut rather than on product specifications (numbers and objective descriptions).		0.1104	
6f. When making decisions, I focus on objective facts rather than subjective feelings.		0.6458	