Pay-What-You-Want in Competition*

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Abstract

This paper presents an analysis of Pay-What-You-Want (PWYW) in competition which explains its entry and limited spread in the market. Sellers choose their pricing schemes sequentially while consumers share their surplus. The profitability and popularity of PWYW depend not only on consumers' preferences, but also on market structure, product characteristics and sellers' strategies. While there is no PWYW equilibrium, given a sufficiently high level of surplus-sharing and product differentiation, PWYW is chosen by later entrants to avoid Bertrand competition. The equilibrium results and their market characteristics are consistent with empirical examples of PWYW.

JEL classification: D11, D21, L11.

Keywords: Pay-what-you-want, competition, product differentiation, market structure.

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1 Introduction

Pay-What-You-Want (PWYW) is a pricing scheme in which a good is up for sale and the consumer, should he decide to buy, chooses the price to pay for it. Despite the standard prediction of consumer free-riding, PWYW has in fact become increasingly popular, arguably due to the extensive media coverage after the success of Radiohead's album "In Rainbows".[1] Many other businesses have followed, the majority selling food and drinks and digital products.[2] In recent years PWYW has also gained much attention in the academic literature, with studies finding that consumers pay a positive amount despite not having to do so (see Greiff and Egbert (2018) for a survey of the literature).

The popularity of PWYW raises the following questions. Under which conditions can we find PWYW and fixed-pricing coexisting in a market? And accordingly, under which conditions does a profit-maximizing entrant choose PWYW pricing? When competitors set a fixed price, even if some consumers are pro-social, heterogeneity in preferences means that the PWYW seller is prone to an adverse selection problem: selfish consumers self-select into the PWYW market and free-ride, causing the seller to make a loss. On the other hand, even if social preference is sufficient to sustain PWYW, the spread of PWYW in the market so far has been limited to sellers with specific characteristics: the majority operate in the food, music and online retail industries (selling digital products) which are characterized by imperfect competition against fixed-price competitors, selling

[1] In 2007, the band Radiohead released their album "In Rainbows" using PWYW. Hundreds of thousands of fans chose to pay a positive amount for the album, and the band in fact profited from this pricing format, making more money than from digital downloads of all their other studio albums combined (see http://musically.com/2008/10/15/exclusive-warner-chappell-reveals-radioheads-in-rainbows-pot-of-gold/, accessed 20-Feb-2019).

[2] See, for example, Kim et al. (2010), Riener and Traxler (2012) and Regner (2015) for cases that have been studied in the academic literature. Other examples are given in online news articles such as https://www.fastcompany.com/3024842/inside-five-businesses-that-let-customers-name-their-own-price, https://www.theguardian.com/lifeandstyle/shortcuts/2018/feb/04/psychology-of-pay-what-you-want-cafes, http://money.com/money/3576844/pay-what-you-want-businesses/, accessed 20-Feb-2019.

non-resalable goods of low marginal cost, with some level of product differentiation. If PWYW has the potential to generate more profits than fixed-pricing, it is puzzling that competitors, and sellers in other industries, have stuck to fixed-pricing.

This paper aims to address the above questions in an industrial organization framework of competing pricing strategies with three or more sellers. Previous studies of PWYW focus primarily on the role of consumer preferences to motivate above zero payments (Kim et al., 2009; Gneezy et al., 2012). With the exception of the duopoly models of Chen et al. (2017) and Chao et al. (2017) which are discussed in the next section, existing theoretical models typically assume a monopolist seller (Isaac et al., 2015; Chao et al., 2015; Kahsay and Samahita, 2015; Mak et al., 2015). Our analysis differs in that we focus on the seller characteristics that are likely to favor PWYW, assuming consumers have social preferences. We study different market structures and extend the analysis to three or more sellers who enter the market and choose their pricing schemes sequentially. Our model generates equilibrium predictions which account for the partial spread of PWYW in the market.

In contrast to prior work, where the success of PWYW has been attributed to consumers' social preferences, we show that this is not enough to induce a seller to adopt a voluntary payment scheme such as PWYW. The emergence of PWYW as an equilibrium strategy also requires certain market and product characteristics. However, when these conditions are fulfilled, PWYW is a simple and cheap strategy that a later entrant can adopt to avoid a tough price competition with the incumbent(s). We compare the model's predictions with the existing examples of PWYW in the market. The parameters that are predicted to sustain the choice of PWYW by a seller include a low marginal cost for the good, a high level (or not too high, in the case of product differentiation) of surplus-sharing, a low proportion of free-riders and an intermediate range of product differentiation

– which are in line with the empirical examples of PWYW.

The main contribution of this paper is explaining the later entry of real world PWYW sellers and their partial spread in the market. We take a different approach from the existing literature by: i) incorporating consumers' social preference in a simple surplus-sharing mechanism, ii) modeling sellers' entry sequentially, and iii) generalizing to three or more sellers. Our unique setting thus provides new insights into the dynamics of sellers' strategies. A first mover will always choose fixed-pricing, while later entrants will only choose PWYW given the above favorable conditions.

The rest of this paper will be structured as follows: related literature is presented in Section 2. We develop the model in Section 3, starting with the monopoly case followed by competition in Section 4. Product differentiation is introduced in Section 5. The results are discussed in Section 6, and Section 7 concludes. All proofs are provided in the Appendix.

2 Related Literature

A large body of PWYW literature has been published in recent years (see, for example, Greiff and Egbert (2018), Gerpott (2017) and Krzyżanowska and Tkaczyk (2016) for reviews). This section aims to highlight several findings from this literature, the questions raised, and the outstanding gaps that our paper seeks to address.

An empirical fact established in the existing papers is that consumers pay a positive amount despite not having to do so (see Kim et al. (2009), Gneezy et al. (2012), Gautier and van der Klaauw (2012) among others). Proposed reasons include a desire to be fair towards the seller (Kim et al., 2009), reciprocity (Regner and Barria, 2009), inequity aversion (Schmidt et al., 2014) and adherence to social norms (Riener and Traxler, 2012). Regardless of the exact mechanism, some level of social preference is a necessary condition for positive payment in one-shot interactions, as will be assumed later in our model.

The existing empirical studies have also found that that the adoption of PWYW has so far been limited to goods of certain characteristics. PWYW products are typically experience goods, digital goods, or goods with low marginal cost (Greiff and Egbert, 2018). Previous theoretical work such as Chen et al. (2017) and Chao et al. (2015) has also confirmed the role played by low marginal cost for the feasibility of PWYW. This is not surprising, since the seller's risk of making a loss due to buyer free-riding is lower the lower the product's marginal cost. This finding can, to some extent, explain why real-life adoption of PWYW is concentrated in the food, music and online retail industries.

Despite the number of PWYW studies available, there are still knowledge gaps regarding how PWYW in reality survives in competition (Natter and Kaufmann, 2015). Greiff and Egbert (2018, p. 189) postulate that "over longer time spans, the success of PWYW pricing will depend on the availability of substitutes and, therefore, on market structure." The food, music and online industries in which PWYW is most prevalent are characterized by some level of product differentiation and imperfect competition against fixed-price competitors. What can explain this particular market structure? To answer this, an analysis of PWYW needs to focus on the seller behavior in competition and address the issue of product differentiation.

While there are a number of PWYW studies that focus on seller behavior, the majority have assumed a monopolist seller (Isaac et al., 2015; Chao et al., 2015; Kahsay and Samahita, 2015; Mak et al., 2015). The lack of research on PWYW's feasibility in competition with other sellers is a clear gap in the literature that has so far only been addressed theoretically in Chen et al. (2017) and Chao et al. (2017), and experimentally in Schmidt et al. (2014) and Krämer et al. (2017).

A major difference between our paper and the papers by Chen et al. (2017) and Chao et al. (2017) is our analysis of sequential entry and generalization to three or more sellers. In Chao et al. (2017), which is a paper closely related to ours (but which we were unaware of upon initially constructing our model), consumers are assumed to be guilt-averse and two sellers of homogeneous products compete in a simultaneous setting. Two equilibrium outcomes are possible: either both firms use fixed-pricing and earn zero profit (the Bertrand result), or one firm chooses PWYW and the other fixed-pricing. Using a simple surplus-sharing mechanism, we replicate their equilibrium results under homogeneous goods competition and furthermore generalize the results with additional sellers and under product differentiation. Chen et al. (2017) integrate product differentiation using a Hotelling city model, which predicts that given sufficiently fair-minded consumers, both firms choose PWYW, otherwise both choose fixed-pricing. Higher level of product differentiation increases the fairness threshold, hence making fixed-pricing more likely. Our model has a different prediction about the effect of product differentiation due to our assumption about transport cost as will be detailed in a later section.

The only laboratory experiments so far that have tested the feasibility of PWYW under competition are Schmidt et al. (2014) and Krämer et al. (2017), both of which use a duopoly setting. In contrast to our prediction of a coexistence equilibrium, given buyers are sufficiently altruistic Schmidt et al. (2014) predict that both sellers use PWYW (Prediction 3). When there is one PWYW seller facing a fixed-price seller, PWYW is predicted to achieve maximum market penetration (Prediction 2). However, the authors concede that this may not hold if buyers still opt for fixed-pricing due to, for example, self-image concerns, and this is indeed what they find with around 20% of buyers still choosing fixed-pricing despite the presence of PWYW. Consequently, given the choice, 85% of sellers also prefer to set a fixed price. However if buyers are not sufficiently altruistic, both papers predict an equilibrium where both sellers choose fixed-pricing. Krämer et al. (2017) compare the performance of PWYW in competition with a fixed-price seller. The authors predict and show that PWYW captures almost the whole market, in contrast to our prediction that a substantial proportion of buyers prefer a fixed price to PWYW. This difference is explained by the assumption that PWYW provides an additional benefit to the seller (through the buzz or word-or-mouth advertising generated), meaning that buyers do not feel bad about accepting a PWYW offer. This assumption will hold in situations where the buzz or media coverage of PWYW is sufficiently large.

3 Model

While the literature on PWYW consumers' social preferences is extensive, a rich model of consumer behavior capturing all the aspects previously mentioned, such as guilt, fairness and reciprocity, will unnecessarily complicate the model. This paper has a different goal and focuses instead on seller behavior. From *the seller's* point of view it is sufficient to observe and take as given that consumers are either free-riders or fair (who may pay more the higher their valuation for the good, as empirically shown in Schmidt et al. (2014) and Krämer et al. (2017), or instead opt out for any of the motivations above). This can be captured in a simple linear model of a consumer who maximizes his net surplus, as done in, for example, Greiff et al. (2014) and Tudón (2015), and in standard industrial organization models of consumer preferences such as Economides (1986) and Perloff and Salop (1985).[3]

Each consumer is assumed to have unit demand. For simplicity, consumer i's total utility from

[3]In Chen et al. (2017), a component for inequity aversion is added to the utility function. Chao et al. (2017) also use a guilt aversion component to model consumer preference. For the purpose of tractability in our analysis of varying market structures, we have opted to use the simpler surplus-sharing mechanism described here.

purchasing the good at price p is assumed linear according to the following:

$$U_i = u_i - p.$$

u_i is the good's consumption utility, or alternatively, i's willingness to pay for the good. It is assumed to be uniformly distributed between zero and k times the good's constant marginal cost $c > 0$, which is public knowledge, so that $u_i \sim U(0, kc)$. k is a scaling term which varies with the support of the consumption utility distribution, to capture the fact that some goods may be valued by consumers more than their marginal cost.[4] Moreover, $k > 1$ so that production of the good is efficient. The population size is normalized to 1, and the utility of no purchase is zero. We assume there is no fixed cost of production. Clearly, as also found in the review by Greiff and Egbert (2018), many PWYW products such as restaurant food and digital music have low marginal costs but high fixed costs. Our motivation for assuming away the latter is based on the following: PWYW is often used as a promotional tool to help cross-sell a complementary product by the same seller. For example, Kish sells drinks and dinner at fixed prices and offer PWYW for lunch guests (Kim et al., 2010). Most hotel rooms are sold at fixed prices and only at specific times is PWYW used (Gautier and van der Klaauw, 2012). If the fixed-price products are sufficiently profitable to cover fixed costs, these costs will not matter for the products sold under PWYW, which is the focus of this analysis.[5]

When the seller lets the consumer pay what he wants (PWYW), this triggers different reactions in consumers depending on the heterogeneous fairness concerns. Assume a proportion θ,

[4]For goods with extremely low marginal cost c, high consumption utility is captured by a high value of k. Alternatively, replacing the upper bound of the consumption utility distribution with $kc + \varepsilon$, $\varepsilon > 0$, produces qualitatively similar results. This also captures the case of goods with zero marginal cost, where ε then acts as a positive fixed cost.

[5]We thank an anonymous referee for this suggestion.

$0 < \theta \leq 1$, are free-riders, who would always take the good for free.[6] Previous studies have consistently found that a proportion of the population of individuals free-ride unconditionally, and that this behavior type is stable (Kurzban and Houser, 2005; Fischbacher et al., 2001). Hence, it is reasonable to assume that θ is an exogenous market parameter, which can vary by country or industry. Cross-country variations in free-riding behavior have been found in Kocher et al. (2008). It is also plausible to consider goods with a charity component to attract fewer free-riders compared to other goods.

The remaining $1-\theta$ consumers, however, are fair: they will pay at least c and therefore will not purchase the good if their consumption utility u_i is less than c. They will even split the surplus $u_i - c$ out of reciprocity for the seller having chosen a PWYW scheme, or any of the previously mentioned social preferences.[7] Let λ be the proportion of surplus shared with sellers, $0 < \lambda \leq 1$.[8] This parameter represents the strength of social preferences in the economy, and can also be interpreted as an exogenous social norm – typically assumed to be 0.5 in an equal sharing rule, but in a richer and more generous economy the norm may be to give more and vice versa (see, for example, Gächter and Herrmann (2009) who find cross-cultural variations in reciprocity).[9]

The fair consumer's PWYW payment is therefore defined to be[10]

$$p_i = c + \lambda(u_i - c).$$

[6]The analysis for $\theta = 0$ is straightforward and is left to the reader.

[7]See also the literature on gift exchange, for example Fehr et al. (1998) where sellers offer high quality and consumers reciprocate by paying prices which are substantially higher than the sellers' reservation prices.

[8]$\lambda = 0$ is simply the case of fixed-pricing at cost.

[9]Assuming that the surplus-sharing parameter is heterogeneous such that λ_i is uniformly distributed with expected value λ yields similar results.

[10]PWYW revenue from fair consumers can therefore be interpreted as that from a two-part tariff, where the surplus-sharing component defines the entry fee and c is the price paid per unit good. To this extent, our analysis in this paper is therefore related to the literature on non-linear pricing.

Observe that since λ and c are assumed exogenous, PWYW payment is deterministic. This means that given the seller offers PWYW, social norms dictate that consumers pay p_i. Substituting this payment into the utility function then gives the consumer's PWYW utility:[11]

$$U_i = u_i - c - \lambda(u_i - c).$$

Again, we stress that social norms dictate that fair consumers do not buy the good if $u_i < c$.

3.1 Monopoly

Under fixed-pricing (FP), a monopolist's profit can be expressed as

$$\pi_{FP} = \int_p^{kc} \frac{1}{kc}(p-c)du = (p-c)\left(1 - \frac{p}{kc}\right)$$

using the familiar $(p-c)q$ notation. Performing the usual profit maximization calculation, we have optimal price, quantity and profit as follows:

$$p_{FP} = \frac{c(k+1)}{2} \qquad q_{FP} = \frac{k-1}{2k} \qquad \pi_{FP} = \frac{c(k-1)^2}{4k}.$$

Under PWYW, a monopolist's profit can be expressed as

[11]This particular choice of reduced-form utility, despite its simple structure and extensive use in the literature cited above, may seem arbitrary and deserve more motivation. Note that this utility function can be derived from, for example, the inequity aversion model of Fehr and Schmidt (1999). If the fair consumer simply compensates the PWYW seller by paying c, he will get a surplus of $u_i - c$ while the seller will get a profit of zero. Advantageous inequity aversion will result in a utility reduction of $\lambda(u_i - c)$, which under PWYW will instead be shared with the seller.

$$\pi_{PWYW} = \theta \int_0^{kc} \frac{1}{kc}(-c)du + (1-\theta)\int_c^{kc} \frac{1}{kc}(c + \lambda(u-c) - c)du$$
$$= \frac{(1-\theta)\lambda c(k-1)^2}{2k} - \theta c.$$

Hence,

Proposition 1. *The monopolist will choose PWYW if and only if*

$$\lambda > \hat{\lambda} = \frac{(k-1)^2 + 4\theta k}{2(1-\theta)(k-1)^2},$$

which increases with θ *and decreases with k.*

Not surprisingly, the condition for PWYW to be chosen over FP is that λ, the level of surplus shared, is high enough, or θ, the proportion of free-riders, is low enough. Additionally, if k, the scaling term corresponding to the support of u_i, is high enough, many fair consumers will have a sufficiently high valuation for the good and thus make a correspondingly high PWYW payment. Thus, PWYW achieves endogenous price discrimination which is more profitable than a fixed-price monopoly. This is illustrated in Figure 1. When the proportion of free-riders is high, PWYW profit is negative. As λ increases and θ decreases such that

$$\lambda > \frac{2\theta k}{(1-\theta)(k-1)^2},$$

PWYW profit becomes positive, but still less than fixed-price profit. Only when λ exceeds the threshold $\hat{\lambda}$ above will PWYW yield higher profit than fixed-pricing. As k increases, the λ-

intercepts of these boundaries stay the same but the curves stretch to the right, increasing PWYW profit.

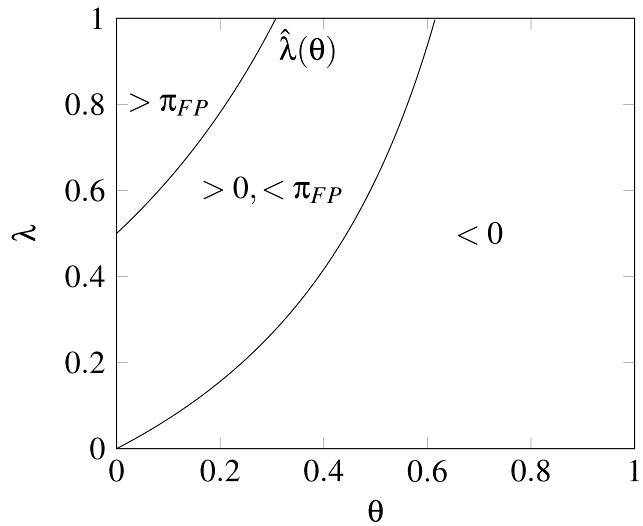


Figure 1: Profit regions for PWYW monopolist, $k = 5$

To illustrate why PWYW is rarely chosen by a monopolist, consider Fehr and Schmidt (1999, Table III) who estimate the proportion of individuals experiencing zero disutility from advantageous inequality to be around 0.3. Using this estimate for the number of free-riders θ suggests that for the seller to choose PWYW over FP, even when λ is very close to 1, requires the good to be valued more than twice its cost on average ($k/2 > 2.40$). As the average level of surplus-sharing decreases, the average valuation needs to increase. In a typical economy with a $\lambda = 0.5$ norm, PWYW profit will never exceed fixed-price profit.

4 Competition

In this section we will present an analysis of homogeneous goods competition with $n > 1$ sellers. Suppose that n competing sellers offer the same product and they can choose their preferred pricing schemes. Assume the product precludes resale.[12] At each stage $s = 1, 2, ..., n$, a seller enters the market and chooses between FP or PWYW. In the last stage $s = n+1$, any seller that chooses FP now chooses his price. If there are multiple FP sellers, the choice of price occurs simultaneously.

The sequentiality in entry closely models what we see in practice, whereby PWYW has commonly entered a market previously dominated by fixed-price sellers.[13] It takes into account frictions such as menu costs, marketing expenses and customer self-selection which are costly and time-consuming, thus preventing sellers from quickly adopting an alternative pricing scheme, at least in the short to medium run. This means that a new entrant is able to observe the choice of pricing scheme of the incumbent(s) and make their own choice taking this knowledge into account. The simultaneity in price competition given multiple FP sellers, however, captures the repeated interaction through the flexibility in prices which sellers can adjust dynamically, once an FP scheme is chosen.[14]

Assuming that FP sellers set profit-maximizing prices, the sequential game for $n = 3$ is depicted in Figure 2. All decisions are common knowledge.

At the end of stage $n+1$, the consumers make their purchase decisions. When all n sellers choose PWYW, consumers randomize such that each seller gets an equal share of the market and shares the monopolist PWYW profit, denoted by A where

$$A = \frac{(1-\theta)\lambda c(k-1)^2}{2nk} - \frac{\theta c}{n}.$$

When all n sellers choose FP, consumers go to the seller with the lowest price or randomize if prices

[12] With resale, an FP competitor or free-riding consumer can drive out the PWYW seller by buying a sufficiently large amount of the good at zero cost to resell them at a positive price.

[13] Assuming simultaneity yields qualitatively similar results.

[14] Letting sellers choose prices sequentially corresponds to a situation in which prices, once set, are fixed.

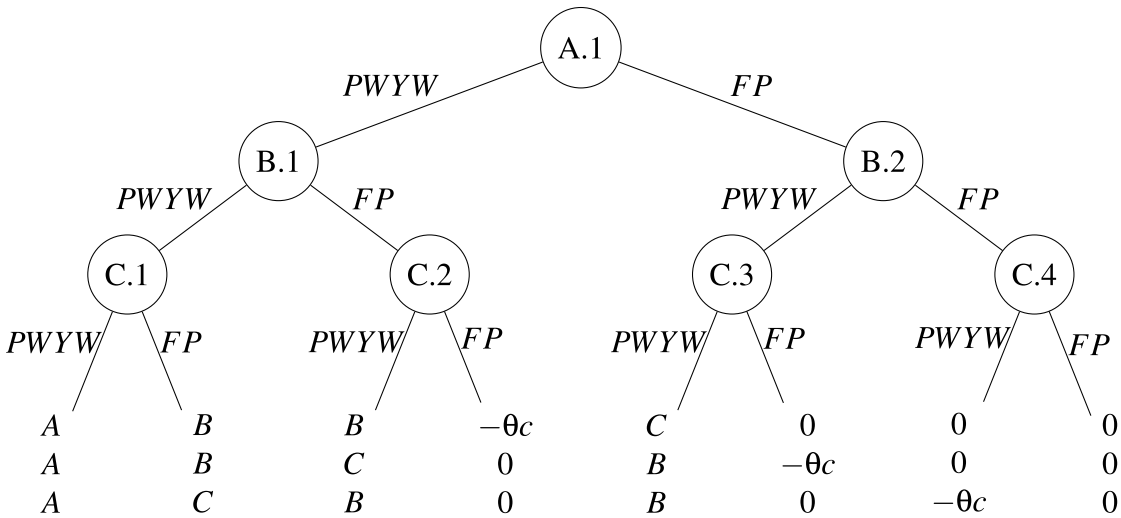


Figure 2: Competition between three sellers

are the same. Hence we assume that the usual Bertrand result applies where all sellers set $p = c$ and make zero profit.

When there are $n-1$ PWYW sellers and one FP seller, the free-riders will randomize among the PWYW sellers which means that each PWYW seller gets $1/(n-1)$ of the free-riders in the market. The fair consumers will go to the seller at which they will pay the lower price, be it the fixed price p or their PWYW price p_i. Going to a PWYW seller means that they are obliged, through fairness norms, to pay p_i. Consumers with high consumption utility may consequently prefer to go to the FP seller and pay a lower fixed price.[15]

At first sight, this choice may seem inconsistent with the fair buyer's motivation to pay a positive price under PWYW. However, it can be argued that when choosing pricing schemes, buyers (who know they will be obliged by social norms to pay a higher price for higher consumption utility under PWYW) simply choose what would in the end give them a higher surplus, and only conditional on

[15]Commonly suggested alternatives where a fair buyer always chooses the PWYW seller and pay the competitor's fixed price less epsilon, or share a proportion of surplus defined as the competitor's fixed price less marginal cost, will not capture the choice of a subset of consumers who prefer to pay a fixed price.

choosing PWYW does the fairness mechanism *appear to* kick in. As per Schmidt et al. (2014, pp. 1222-1223), "some customers may opt for a [FP] seller because they are happy to buy the product for a low posted price, but they would feel 'cheap' if they paid this low price voluntarily."[16] The assumption that (even fair) consumers choose the seller at which they can pay a lower price is crucial to capture the preference for fixed-pricing seen in empirical examples (Gneezy et al., 2012; Kim et al., 2009).

Define

$$u_p = c + \frac{p-c}{\lambda}$$

to be the consumption utility at which a fair consumer is indifferent between paying p_i, his PWYW payment, and the fixed price p. Therefore, when $c \leq u_i < u_p$, he prefers to choose PWYW and randomize among the $n-1$ PWYW sellers, when $u_i = u_p$ he is indifferent, and beyond u_p he is better off purchasing at the fixed price than sharing his consumer surplus with a PWYW seller. This is illustrated in Figure 3.

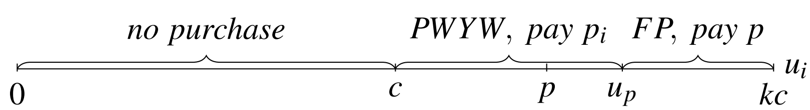


Figure 3: Fair consumer's action when PWYW and fixed-pricing both exist

Clearly the fixed-price seller chooses the profit-maximizing price p taking into account that this price will determine demand for both himself and his PWYW competitors. He will no longer get all the consumers with valuation greater than p since the θ free-riders go to the PWYW sellers.

[16] While in our seller-focused model the fair buyer's PWYW price is deterministic, studies focusing on buyer behavior argue that PWYW involves a certain degree of uncertainty regarding the correct behavior (Park et al., 2017): what is the "right" price to pay? Should I pay a high amount to be sure that I have complied with the expectation of the seller or should I save a bit of money and incur guilt or image loss instead? Some consumers may seek to avoid this moral deliberation and obligation by paying a fixed price (Schmidt et al., 2014). There is also evidence in the experimental literature where subjects avoid information if the resulting moral wiggle room allows them to behave selfishly (Dana et al., 2007).

Out of the fair consumers, he will only get those with $u_i \geq u_p$ (see Figure 3). Hence the fixed-price seller will not set $p \geq c(\lambda k - \lambda + 1)$, as $u_p \geq kc$ and he would then get no customer. He will also not set $p \leq c$, as this will yield zero or negative profit. Therefore his fixed price will lie in $(c, c(\lambda k - \lambda + 1))$, and his profit can be expressed as[17]

$$\pi_{FP} = \frac{1-\theta}{kc} \int_{u_p}^{kc} (p-c)du.$$

The profit-maximizing price is thus

$$p^* = c\left(1 + \frac{\lambda(k-1)}{2}\right)$$

and $u_p = c(k+1)/2$. Hence, the FP seller earns

$$C = \frac{(1-\theta)\lambda c(k-1)^2}{4k},$$

while the $n-1$ PWYW sellers share the remaining fair consumers and free-riders resulting in each earning

$$B = \frac{(1-\theta)\lambda c(k-1)^2}{8(n-1)k} - \frac{\theta c}{n-1}.$$

When two or more sellers choose FP and the remaining seller(s) chooses PWYW, all free-riders go to the PWYW seller(s). The fair consumers will again choose the lower of $\{p, p_i\}$ where their indifference point is as illustrated in Figure 3. However, with two or more FP sellers competing in price we obtain a Bertrand outcome: competition will drive down the price to marginal cost.

[17]The set $(c, c(\lambda k - \lambda + 1))$ is non-empty since $\lambda > 0$ and $k > 1$.

Consequently, $u_p = c$, all fair consumers will randomize among the FP sellers and none will choose to buy from the PWYW seller(s). Each FP seller earns zero profit while the PWYW seller(s) incurs a (shared) loss of $-\theta c$ from exclusively selling to free-riders.

The resulting profit for each seller is shown in Figure 2. To describe the equilibrium results, define the following:

Definition 1. *In an **FP equilibrium**, all sellers choose FP.*

Definition 2. *In a **PWYW equilibrium**, all sellers choose PWYW.*

Definition 3. *In a **coexistence equilibrium**, both PWYW and FP exist in the market.*

The equilibrium outcomes will now be summarized in Proposition 2, and illustrated in Figure 4.

Proposition 2. *Given*

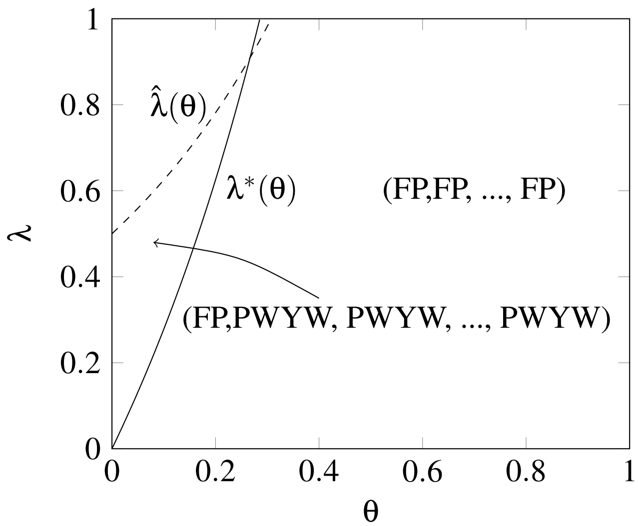
$$\lambda^* = \frac{8\theta k}{(1-\theta)(k-1)^2},$$

which increases with θ and decreases with k, when n competing sellers choose pricing schemes sequentially and then enter into a simultaneous price competition, the subgame perfect equilibrium is either coexistence or FP. Specifically,

i if $\lambda > \lambda^*$, the first seller to enter the market chooses FP, while all subsequent entrants choose PWYW.

ii if $\lambda \leq \lambda^*$, all sellers choose FP.

In equilibrium, either all n sellers compete in a Bertrand price competition and earn zero profit, or if there is sufficiently high surplus-sharing in the market every new entrant will choose PWYW



Dashed line represents the corresponding monopolist threshold $\hat{\lambda}$ above which PWYW is chosen.

Figure 4: Subgame perfect Nash equilibria, $k = 5$

to avoid price competition against the FP first mover. As long as λ is sufficiently high or θ is sufficiently low, there is positive residual PWYW profit and later entrants will choose PWYW, with the first mover reaping the majority of the market profit. This is anticipated by the first mover, who would thus always choose FP. Only when the PWYW profit becomes negative do later entrants prefer the Bertrand competition. All pure strategy equilibria are unique.

Note that λ^* decreases as k, and hence the support of u_i, increases. As the good becomes more valuable to consumers, choosing PWYW becomes more profitable for later entrants as their residual profit (when the first mover has chosen FP) increases. Setting $\theta = 0.3$ (Fehr and Schmidt, 1999), the average valuation of the good needs to be at least 2.62 times its cost for PWYW to be chosen by later entrants, even when λ is very close to 1 which is not often seen in practice. When $\lambda = 1/2$, the average valuation needs to be even higher (4.37) which may be less realistic. On the other hand, we see that for low values of θ it is possible to sustain PWYW sellers in competition for lower values of λ compared to the monopoly situation.[18] This is due to the opportunity cost of

[18]This relationship is reversed if $\theta > (k-1)^2/12k$ and $k < 13.93$. In this region it is more difficult for PWYW

adopting FP: as a monopolist, choosing FP leads to positive profit, while the Bertrand competition profit is zero. Hence the switching point to FP occurs at a higher value of λ as a monopolist than in competition.

It might appear that our results are simply driven by the zero profit feature of the Bertrand model, that given PWYW is sufficiently profitable it would naturally be chosen as an alternative to fixed-pricing. While this explains the choice of the second mover at node B.2 in Figure 2, we argue that the equilibrium path at other nodes, for example B.1, and hence A.1, is not necessarily obvious. Given a first mover choosing PWYW, our model predicts that the second mover would reap more profit using a fixed price. This relies on our assumption that consumers with high valuation would rather pay a fixed price than face the moral obligation of paying a higher price under PWYW, in contrast to other predictions such as Schmidt et al. (2014) where full market penetration under PWYW leads to the PWYW equilibrium.

Assuming $n = 2$ allows for comparisons against previous theoretical models of PWYW in duopoly competition. Our model yields an FP equilibrium if $\lambda \leq \lambda^*$ and a coexistence equilibrium where the first mover chooses FP and the second mover chooses PWYW otherwise. This is similar to the results in Chao et al. (2017), where consumers are assumed to be guilt-averse and sellers compete in a simultaneous setting. However our equilibrium results differ from those in Chen et al.'s (2017) model with product differentiation where setting transport cost equal to zero yields the PWYW equilibrium. The difference stems from their assumption of no free-riders, which is relaxed here, and the way that fair consumers choose their seller when both PWYW and FP are available. In Chen et al. (2017), surplus is defined according to the 'next best option': given the FP

to survive competition, as the lower proportion of fair buyers contributes even lower profit due to the presence of the FP competitor. However, as can also be seen in Figure 4, the existence of this case also requires $\lambda \approx 1$ which is less common.

seller's price p, the fair consumer's PWYW payment is $c+\lambda(p-c)$, which is always less than p if $\lambda < 1$. This means that all consumers will buy from the PWYW seller, and consequently there is no equilibrium with PWYW competing against FP. This contrasts with our definition of surplus-sharing and our assumption of heterogeneous consumption utility, giving rise to fair consumers who do not buy at all, those who buy from the PWYW seller, and those who go to the FP seller to pay a fixed price, thus yielding the coexistence equilibrium.

In summary, no equilibrium exists where all sellers choose PWYW. Instead, PWYW is used as a strategy by later entrants to avoid Bertrand competition. Consequently, this makes PWYW a simple and cheap alternative to other costly marketing strategies such as differentiating products or introducing switching costs. For the first mover, the 'threat' of a competitor choosing PWYW is likewise beneficial in preventing the Bertrand equilibrium of zero profit.

5 Product Differentiation

Almost all products in the market are differentiated in some dimension and goods that are completely homogeneous are extremely rare. However, even taking this into consideration, many PWYW examples seem to be concentrated in markets where the level of differentiation is intermediate, such as food, music and other digital products. While adopting PWYW seems to be more profitable for relatively imperfect substitutes than close-to-homogeneous goods, the adoption of PWYW does not quite reach the other extreme: products which are highly differentiated through exclusive brand names are still sold predominantly at fixed prices. In this section, we study a model of PWYW competition with product differentiation which can explain this finding.

Assume three sellers A, B, and C are evenly spaced on a Salop circular city with circumference 1.[19] The sellers are thus located at $x = 0, 1/3, 2/3$ respectively. Consumers are uniformly distributed on the circumference. We continue to assume unit demand. For simplicity, and as commonly assumed in models of horizontal product differentiation including Hotelling (1929), consumption yields constant surplus $v = E(u) = kc/2$ as firms are assumed to be risk-neutral. This is a considerable simplification from the homogeneous product model with heterogeneous consumption utility studied in previous sections, however it facilitates the analysis to generate tractable results under product differentiation.

Consumers pay a transportation cost $t > 0$, such that a consumer located at $x \in [0, 1/3]$ incurs disutility tx if he purchases from Seller A located at 0, and $t(1/3 - x)$ from Seller B located at 1/3. The transport cost is the only factor differentiating the goods sold at the three different sellers, which means that each consumer will only consider buying from the two sellers closest to him. The consumer above will thus never buy from Seller C located at 2/3. All three sellers have the same profit and cost structures as before, with constant marginal cost c. We assume also that v, and hence k, is sufficiently large such that the market is fully covered: all consumers will purchase a unit in equilibrium.

Sellers choose their pricing scheme sequentially and prices are set at the end (simultaneously, if all sellers choose FP). With all sellers choosing FP, the equilibrium outcome is simple to calculate: all sellers set $p_A = p_B = p_C = c + t/3$ and get a third of the market with profits $\pi_A = \pi_B = \pi_C = t/3$.[20] This result is intuitive: the higher the degree of differentiation, the higher the sellers are able

[19] We assume three sellers to obtain an insightful yet tractable analysis. Assuming two sellers with both Salop's circular city and Hotelling's linear city yield the same qualitative results.

[20] A consumer at $x \in [0, 1/3]$ will be indifferent to purchasing at either Seller A or Seller B if his utility from purchasing at Seller A, $U = v - p_A - tx$, equals the utility from purchasing at Seller B: $U = v - p_B - t(1/3 - x)$. His location is thus $x = (p_B - p_A + t/3)/(2t)$. Hence, from maximizing $\pi_A = (p_A - c)x$ with respect to p_A and by symmetry, we get $p_A = p_B = p_C = c + t/3$ and $x = 1/6$. That is, the indifferent consumer for each pair of sellers is located exactly in the middle of each of the three arcs.

to charge in mark-up over the cost of the good, while in the limit as $t \to 0$ we get the Bertrand equilibrium again.

Suppose now that all sellers adopt PWYW. When the consumer buys from a PWYW seller, his PWYW payment continues to be defined by the surplus-sharing mechanism as per Section 3: $p_i = c + \lambda(v - c)$. Note that we have assumed the surplus-sharing component is derived from the consumer's total surplus from the good, not counting any reduction from transport cost. Transport cost moderates product differentiation insofar as it determines the consumer's choice of sellers, without creating heterogeneity in PWYW payment. We argue that this is a realistic representation of a fair consumer who has to consume a good slightly different from his first choice, but upon arriving at the seller, in keeping with social norms pays according to the good's pure consumption utility, without penalizing the seller for the extent of product differentiation.[21]

For clarity in the analysis, assume no free-riders. The utility of a consumer located at $x \in [0, 1/3]$ who buys from Seller A is $U = v - tx - (c + \lambda(v - c))$, while from Seller B his utility is $U = v - t(1/3 - x) - (c + \lambda(v - c))$. As the payment for the good is identical at both sellers, the indifferent consumer is located exactly in the middle of the arc at $x = 1/6$. Each of sellers A and B thus serves half the consumers in the arc $[0, 1/3]$. Applying this logic to the remaining two arcs, all three sellers share the market equally and $\pi_A = \pi_B = \pi_C = \lambda(v - c)/3$. This is independent of the transport cost: when the consumer pays what he wants, his payment is deterministic. Consequently each seller always gets a third of the PWYW market profit regardless of the degree of product differentiation.

Suppose now that there are two PWYW sellers and 1 FP seller in the market: Seller A adopts

[21] While this is mainly done for tractability, it is a common interpretation that transport cost is not paid to the seller. Consequently the transport cost t merely determines the consumers' choice of sellers, and once this choice is made, p_i is paid.

FP, Seller B adopts PWYW and Seller C adopts PWYW. Consider again the arc $[0,1/3]$. The indifferent consumer is now located at $x = (t/3 - p_A + c + \lambda(v-c))/(2t)$. Since Seller A faces the same competition against a PWYW seller in the arc $[2/3,0]$, his total demand is thus equal to $2x$. It is straightforward to derive the profit maximizing price of Seller A:

$$p_A = c + \frac{t/3 + \lambda(v-c)}{2}$$

which implies

$$x = \frac{1}{12} + \frac{\lambda(v-c)}{4t}$$

and profits are

$$\pi_A = \frac{1}{t}\left(\frac{t}{6} + \frac{\lambda(v-c)}{2}\right)^2.$$

For Seller B, his total demand is $1/3 - x$ in the arc $[0,1/3]$ and 1/6 in the arc $[1/3,2/3]$ since he shares the demand equally with the PWYW competitor Seller C at 2/3. PWYW profits are thus

$$\pi_B = \pi_C = \frac{5\lambda(v-c)}{12} - \frac{\lambda^2(v-c)^2}{4t}.$$

Suppose now there are two FP sellers and 1 PWYW seller in the market: Seller A again adopts FP, Seller B adopts PWYW and Seller C adopts FP. The total demand faced by Seller A is thus $x = (t/3 - p_A + c + \lambda(v-c))/(2t)$ in the arc $[0,1/3]$ and 1/6 in the arc $[2/3,0]$. The profit maximizing price for both Seller A and Seller B is thus

$$p_A = p_B = \frac{2t}{9} + c + \frac{\lambda(v-c)}{3}.$$

This implies that

$$x = \frac{1}{18} + \frac{\lambda(v-c)}{3t}.$$

FP profits are thus

$$\pi_A = \pi_C = \frac{1}{t}\left(\frac{2t}{9} + \frac{\lambda(v-c)}{3}\right)^2$$

while PWYW profits are

$$\pi_B = \frac{5\lambda(v-c)}{9} - \frac{2\lambda^2(v-c)^2}{3t}.$$

The equilibrium results are stated in the following proposition:

Proposition 3. *When three competing sellers of differentiated products choose pricing schemes sequentially and then enter into a simultaneous price competition, the subgame perfect equilibrium is either coexistence or FP. Specifically, each seller's strategy in order of entry is:*

i *if* $\lambda < t/(3(v-c))$, *(FP,FP,FP),*

ii *if* $\lambda = t/(3(v-c))$, *all sellers randomize and thus all eight combinations of PWYW and FP by the three sellers are equilibrium outcomes,*

iii *if* $t/(3(v-c)) < \lambda < 16t/(39(v-c))$, *(FP,PWYW,PWYW),*

iv *if* $16t/(39(v-c)) \leq \lambda < t/(2(v-c))$, *(FP,FP,PWYW),*

v *if* $\lambda = t/(2(v-c))$, *the first two entrants choose FP while the third entrant randomizes between PWYW and FP,*

vi *if* $\lambda > t/(2(v-c))$, *(FP,FP,FP).*

In short, the first mover always chooses FP. If the second mover chooses PWYW, the third mover always follows with PWYW. In no equilibrium do all sellers choose PWYW except when $\lambda = t/(3(v-c))$ where all profits are the same regardless of pricing scheme and all sellers randomize.

All pure strategy equilibria are unique. When the surplus-sharing norm is low, PWYW is attractive to consumers but yields low profit to the seller and hence FP is preferred by all sellers. As λ increases, PWYW becomes more attractive to sellers facing FP competitor(s), while demand is still sufficiently high. In the region $t/(3(v-c)) < \lambda < 16t/(39(v-c))$, two PWYW sellers are supported in the market. As λ continues to increase, PWYW profitability continues to increase but demand decreases at the same time as the PWYW good becomes more "expensive" due to the high surplus-sharing norm. In $16t/(39(v-c)) \leq \lambda < t/(2(v-c))$ only one PWYW seller is supported in the market. When $\lambda > t/(2(v-c))$ demand is insufficient for even one PWYW seller and hence all three sellers choose FP.

As seen above, variations in k (and hence v), c and t affect the range of values for which PWYW obtains. As consumer valuation k increases, v also increases and all of the threshold values for λ in Proposition 3 decrease. On the one hand, PWYW becomes more attainable for lower values of surplus-sharing, but when surplus-sharing is high PWYW is less appealing for consumers as the amount paid to the PWYW seller increases. The effect of marginal cost c is similar: all thresholds of λ are decreasing in c. For low values of λ, as c increases, $v = kc/2$ also increases and the higher valuation for the good increases PWYW profit. However, when λ is high, the higher PWYW payment results in lower demand making fixed-pricing more profitable.

The effect of varying t, the degree of product differentiation, is the precise opposite: as t increases, all thresholds for λ in Proposition 3 also increase. This means that an equilibrium of three

FP sellers can be turned into a coexistence equilibrium with PWYW when λ is sufficiently high, while a coexistence equilibrium may no longer obtain when λ is low.

Consider the limiting case with homogeneous products: as $t \to 0$, an FP seller facing two PWYW competitors can simply set $p = c + \lambda(v - c) - \varepsilon$ and capture all adjacent consumers and hence 2/3 of the market. Therefore, an increase in t serves to guarantee that some consumers will go to the PWYW seller as the location of the indifferent consumer x moves closer to the FP seller. With two FP sellers and one PWYW seller, an increase in t also drives demand to the PWYW seller from the two FP sellers who no longer set $p = c$. In both cases, an increase in t serves to increase demand for the PWYW seller when there are FP seller(s) in the market. However, this increase in demand will only convince an FP seller to switch to PWYW when the level of surplus-sharing norm is above the thresholds given in Proposition 3 vi (where FP was chosen due to low demand), that is, in the range

$$\frac{t_0}{2(v-c)} < \lambda < \frac{t_1}{2(v-c)}.$$

When the level of surplus-sharing is low such that PWYW results in high demand but is not sufficiently profitable, yet another increase in demand from product differentiation will not induce the FP seller to switch to PWYW as the amount paid by each consumer is still too low to overtake the profit increase as an FP seller. In fact, in the range

$$\frac{t_0}{3(v-c)} < \lambda < \frac{t_1}{3(v-c)}$$

an FP equilibrium will obtain in place of the (FP,PWYW,PWYW) equilibrium.

It is worth discussing the key differences between this model and that in Chen et al. (2017).

Besides the extension to a Salop model with three competitors, we have assumed here that the transport cost is not included in the surplus-sharing calculation: once the consumer 'arrives' at the PWYW seller, he considers his surplus to be the pure consumption utility less the cost of the good. In Chen et al. (2017), the consumer utility from purchasing at the PWYW seller is defined to be $U = v - tx - (c + \lambda(v - tx - c))$. When the consumer has the choice of PWYW and FP sellers, his surplus is defined to be $p_t - c$, in line with the 'next best option' where p_t is the (fixed) price at which he is indifferent between buying from either seller. As a result, the location of the indifferent consumer and hence demand is independent of λ, the surplus-sharing parameter. The FP profit is lower compared to that derived here, giving rise to a PWYW equilibrium whenever λ exceeds a threshold value which is increasing in transport cost, or an FP equilibrium otherwise. While the FP equilibrium is consistent with the results obtained here, we do not empirically observe a market dominated by PWYW. Moreover, we find that the relationship between surplus-sharing, transport cost and the likelihood of PWYW in equilibrium is also not as straightforward as Chen et al. (2017) suggest: while a higher level of surplus-sharing makes PWYW more profitable, given our assumptions above this is only true up to a point, beyond which higher surplus-sharing will drive away customers to the fixed-price competitor. Similarly, given a sufficiently high surplus-sharing norm, as the level of product differentiation increases, PWYW is more profitable up to a point, beyond which FP would be preferred.

6 Discussion

This paper studies the conditions under which PWYW obtains in a competitive equilibrium against fixed-pricing, which has so far received little attention in the literature. In this section, the results from the analysis will be discussed in relation to the empirical examples of PWYW and those found in the academic literature.

Our first finding is that PWYW is easier to obtain in competition relative to a monopoly. As shown in Figure 4, even for low levels of free-riding, a PWYW monopolist requires a higher level of surplus-sharing norm in the market relative to competition. Not surprisingly, empirical examples of PWYW monopolists are rare and to the best of our knowledge limited to a few instances of football matches or museums who use PWYW for certain customer segments.[22]

Second, PWYW is also more likely to obtain in settings with higher surplus-sharing and lower free-riding, for example when payments include a charity component.[23] In the behavioral literature, a charity component increases the image-sensitivity of the buyer (Gravert, 2017), which is expected to increase the level of surplus-sharing and reduce free-riding, as the latter results in image loss for the consumer. A lower free-riding parameter additionally decreases the threshold level for surplus-sharing, thus further increasing the likelihood of PWYW in competition. The use of a charity component has successfully sustained PWYW for businesses such as Humble Bundle.[24] In other markets where sellers face a high number of free-riders, PWYW is unlikely to succeed.[25] Consistent with our assumption of an exogenous surplus-sharing norm, the trend of successes and failures of PWYW has been attributed to cultural factors where PWYW does well in countries with high taxes and strong social welfare systems,[26] these are countries where social norms for cooperation are relatively strong (Herrmann et al., 2008).

[22] See https://www.bbc.com/news/uk-england-33609867, https://www.bbc.com/sport/football/30715162, https://rsecure.metmuseum.org/admissions, accessed 20-Feb-2019.

[23] While a charity component can in practice be used as a strategic choice by the seller, it is assumed to be exogenous in our model, as captured by λ.

[24] See http://www.techdirt.com/blog/entrepreneurs/articles/20100716/17423610253.shtml, accessed 20-Feb-2019.

[25] See http://www.bbc.com/capital/story/20140120-a-recipe-for-disaster, accessed 20-Feb-2019.

[26] Ibid.

A third insight is that PWYW is more likely to obtain in markets with some level of product differentiation, either through product characteristics or geography. Examples of homogeneous products sold under PWYW are rare.[27] As predicted in Proposition 3 of our model, given sufficiently high surplus-sharing an increase in product differentiation makes PWYW more feasible. Furthermore, PWYW businesses that operate from a physical store or restaurant not only benefit from geographical product differentiation. The more personal nature of the transaction generates lower social distance which serves to encourage a higher surplus-sharing norm, thus benefiting PWYW relative to an anonymous online transaction (Hoffman et al., 1996; Regner and Riener, 2017). What then explains the common use of PWYW for digital products? Our model suggests that the lack of geographical differentiation is compensated by a low or zero marginal cost. As seen in Proposition 3, if c is almost zero while the products are still sufficiently differentiated, PWYW can be sustained in equilibrium.[28] As has also been shown in previous studies, a low marginal cost is a standard requirement for a seller to be able to sustain PWYW (Chen et al., 2017; Krämer et al., 2017; Chao et al., 2015).

A final takeaway from our model concerns the sequentiality of entry for the sellers. In all coexistence equilibria, with and without product differentiation, PWYW is always chosen by a later entrant, thus avoiding price competition with the FP incumbent(s). This is a trend that is also observed empirically. For example, Kish restaurant was a new entrant in Frankfurt's (fixed-price dominated) restaurant market when the owner decided to adopt PWYW on their lunch menu as

[27]To the best of our knowledge, examples of PWYW products that are close to homogeneous are limited to loan interest (`https://www.earnin.com/`), money transfer service (`https://www.xendpay.com/`), and a tax software (`https://simpletax.ca/`), all accessed 20-Feb-2019.

[28]For homogeneous goods analyzed in Section 4, a high value of marginal cost c correspondingly makes a high value of k unreasonable, due to consumers' budget constraints. As the threshold value of surplus-sharing λ, which must be exceeded for PWYW to be chosen, is decreasing in k, a low marginal cost also indirectly makes PWYW more attainable.

it was found to be more profitable than fixed-pricing (recounted in Kim et al. (2010)). Another example is the company Earnin (previously Activehours) which lets customers access their pay before payday, essentially borrowing money with PWYW interest. It entered a homogeneous, fixed-price market, and has instead chosen to let customers pay what they want in an effort to gain their trust and appeal to their generosity.[29] Using PWYW is desirable as a response to fixed-pricing by incumbent, however, it is unlikely to be chosen by a first mover in a new industry.

7 Conclusion

This paper aims to explain the mixed popularity of PWYW pricing schemes in different sectors. Many PWYW examples can be found in imperfectly competitive markets with some level of product differentiation, but few PWYW examples exist in perfect competition or as monopolists. While previous PWYW literature has studied consumers' social preferences and their behavior when facing a PWYW seller, we focus on the seller's choice between fixed-pricing and PWYW while still retaining the social preference of consumers in a surplus-sharing mechanism. Sellers' strategies are studied in various types of markets where entry occurs sequentially, allowing us to capture the commonly later entry of a PWYW seller into a fixed-price dominated market. We show that the profitability of PWYW, and hence its popularity, depends not only on the preferences of consumers but also on the market structure, product characteristics and sellers' strategies. There is no equilibrium in which PWYW dominates the market. Given a sufficiently high level of surplus-sharing and product differentiation, PWYW can be chosen by later entrants as a simple strategy to avoid Bertrand competition. While the problem of adverse selection persists, in which PWYW attracts

[29]See `http://www.mobilebeyond.net/activehours-ceo-says-employees-owed-2t/`, accessed 20-Feb-2019.

the free-riders and fair consumers with low valuation, in some cases this is still more profitable than entering into a price competition with the incumbent. If the level of surplus-sharing is too low, fixed-pricing dominates. These results are consistent with well-known empirical examples of PWYW.

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Appendices

A Proofs

A.1 Proposition 1

$$\pi_{PWYW} = \frac{(1-\theta)\lambda c(k-1)^2}{2k} - \theta c > \frac{c(k-1)^2}{4k} = \pi_{FP}$$

implies

$$\lambda > \frac{(k-1)^2 + 4\theta k}{2(1-\theta)(k-1)^2} = \hat{\lambda}.$$

For existence of PWYW in equilibrium, it is easy to show that the set $\hat{\lambda} < 1$ is non-empty. It is also straightforward to derive the following:

$$\frac{d\hat{\lambda}}{d\theta} = \frac{(k+1)^2}{2(1-\theta)^2(k-1)^2} > 0 \qquad \frac{d\hat{\lambda}}{dk} = -\frac{2\theta(k+1)}{(1-\theta)(k-1)^3} < 0.$$

A.2 Proposition 2

First note that whenever there are at least two FP sellers already in the market, the next entrant will always choose FP. With at least two FP sellers in the market, price equals marginal cost and fair buyers will always choose FP, resulting in the PWYW seller(s) incurring a loss from catering to the demand of free-riders. Hence for any subsequent entrant it is better to set a fixed price and get zero profit than choose PWYW and get negative profit. The same logic also applies whenever the current entrant anticipates that there would be at least two future FP sellers.

When there is one FP seller already in the market, if the next entrant chooses FP he would get zero profit from the price competition. If he chooses PWYW, his profit depends on λ.

- If $\lambda < \lambda^*$, PWYW profit is always negative whenever there is at least one FP competitor, regardless of what future entrants choose. Hence, he would rather choose FP himself than end up with a loss.

- If $\lambda > \lambda^*$, future entrants will also choose PWYW (that is, future entrants would avoid creating price competition with the other FP seller) since in a market with only 1 FP seller the PWYW sellers get positive profits:

$$B = \frac{(1-\theta)\lambda c(k-1)^2}{8(n-1)k} - \frac{\theta c}{n-1} > 0.$$

  Hence he would choose PWYW.

- If $\lambda = \lambda^*$, and all subsequent entrants except the very last entrant choose PWYW, the very last entrant will randomize since $B = 0$. The positive probability that the very last entrant chooses FP will however yield negative expected profit for the second last entrant, who would then rather choose FP and be assured of a zero profit. All sellers will thus expect that in total there would be at least two FP sellers, and consequently no seller would risk choosing PWYW and having to serve only free-riders.

In short, when there is one FP seller already in the market, the next entrant will always choose FP except if $\lambda > \lambda^*$ in which case all subsequent sellers will also choose PWYW.

Suppose now there is no FP seller currently in the market. The choice of the next entrant is as follows.

- If $\lambda < \lambda^*$, choosing FP will result in all subsequent sellers choosing FP as per the above, yielding zero profit. If he and all future entrants but the last one choose PWYW, the very last entrant would choose FP since being the only FP seller yields a higher profit than sharing the monopolist PWYW profit (since $C > A$). The second last mover will thus prefer to choose FP and get zero profit, since $B < 0$. Hence, by backward induction, since each seller anticipates there would be at least two subsequent FP sellers, any other previous seller will choose FP.

- If $\lambda > \lambda^*$, if he chooses FP he would be the only FP seller in the market since all subsequent entrants would prefer to earn positive PWYW profit ($B > 0$) than compete in price and earn zero profit. His own profit will thus be C, which is greater than any profit he could get as a PWYW seller. He will thus take the chance to be the only FP seller.

- If $\lambda = \lambda^*$, and all subsequent entrants but the very last one choose PWYW, the very last entrant will choose FP and be the only FP seller in the market earning C, while all previous PWYW entrants would earn $B = 0$. The second last entrant would thus rather choose FP, let the last entrant randomize, and earn an expected profit of $C/2$. For the third last entrant, choosing PWYW earns him 0 at most. If he chooses FP and is the only FP seller in the market thus far, the next entrant will choose FP by the logic above while the last entrant will randomize. Thus, no matter the choice of the current seller, there will always be at least one future entrant choosing FP in addition to the probability 0.5 that the very last mover chooses FP. This means that the current seller will also prefer FP than risk negative expected profit from having to serve only free-riders.

In short, when there is no FP seller currently in the market, the next entrant will always choose FP.

It is easy to see that the arguments above hold for all $n \geq 2$. Thus, the first mover will always choose FP. If $\lambda > \lambda^*$, the second mover will choose PWYW, which will be imitated by all subsequent movers. If $\lambda \leq \lambda^*$, the second and all subsequent movers will also choose FP. These results are summarized in Proposition 2.

For the existence of PWYW in equilibrium, it is easy to show that the set $\lambda^* < 1$ is non-empty. It is also straightforward to derive the following:

$$\frac{d\lambda^*}{d\theta} = \frac{8k}{(1-\theta)^2(k-1)^2} > 0 \qquad \frac{d\lambda^*}{dk} = -\frac{8\theta(k^2+k-1)}{(1-\theta)(k-1)^4} < 0.$$

A.3 Proposition 3

The game tree in Figure 5 captures the profit structure of the competition between there sellers with product differentiation. Define the following:

$$A = \frac{5\lambda(v-c)}{12} - \frac{\lambda^2(v-c)^2}{4t}$$

$$B = \frac{1}{t}\left(\frac{t}{6} + \frac{\lambda(v-c)}{2}\right)^2$$

$$C = \frac{5\lambda(v-c)}{9} - \frac{2\lambda^2(v-c)^2}{3t}$$

$$D = \frac{1}{t}\left(\frac{2t}{9} + \frac{\lambda(v-c)}{3}\right)^2.$$

First note that at C.1

$$\frac{\lambda(v-c)}{3} < B$$

unless

$$\lambda = \frac{t}{3(v-c)},$$

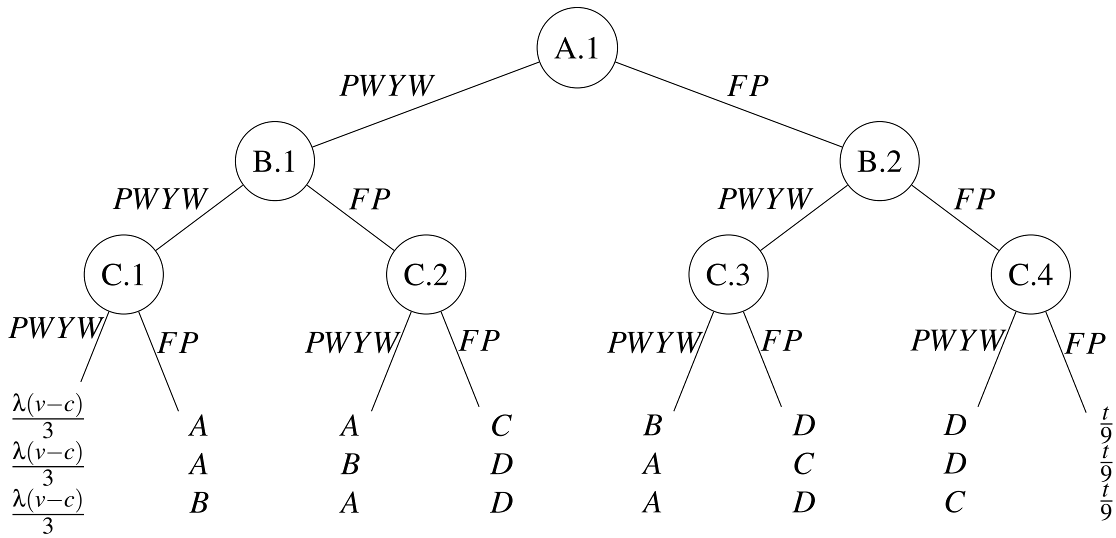

Figure 5: Competition between three sellers with product differentiation

in which case

$$A = B = C = D = \frac{\lambda(v-c)}{3} = \frac{t}{9}$$

and all sellers are indifferent between PWYW and FP.

At node C.4, the third mover will always choose FP unless $C > t/9$ or

$$\frac{t}{3(v-c)} < \lambda < \frac{t}{2(v-c)}.$$

At nodes C.2 and C.3, the third mover will always choose FP unless $A > D$ or $t/(3(v-c)) < \lambda < 16t/(39(v-c))$.

All that remains is to check the choice of the second and first movers given the various regions for λ, yielding the equilibrium outcomes given in Proposition 3.