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RESEARCH ARTICLE

THE COST OF FREE: THE EFFECTS OF "WAIT-FOR-FREE" PRICING SCHEMES ON THE MONETIZATION OF SERIALIZED DIGITAL CONTENT [1]

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Leveraging a combination of analytical frameworks and empirical assessments, this study investigates the effects of wait-for-free (WFF) pricing schemes on the monetization of serialized, digital entertainment content, which has become increasingly pervasive on online platforms. WFF pricing is a strategy in which consumers are given the option to either wait a certain amount of time to acquire digital content at no cost or pay to consume it immediately. We evaluate the extent to which habit formation and present-biased preferences driven by the consumption of addictive stock affect individual consumers' willingness to wait (or pay) for content, which, in turn, determines the efficacy of WFF pricing. We also examine the conditions under which consumers switch from waiting for free content to instantaneously purchasing content. Our findings indicate that WFF pricing increases the sales of serialized digital content, generating new demand from customers who would otherwise forgo participation in the market. In addition, the pricing design effectively generates sustained profits in the long run. We found that most consumers who initiate a purchase either upon initial market entry or upon switching continue to purchase as new episodes become available. Moreover, the results indicate that as a user accumulates free episodes of a specific series, given extended waiting periods, the likelihood of their conversion from a wait-for-free customer to an instant-purchase customer increases. In particular, WFF pricing effectively augments the willingness to pay of low-valuation consumers as habit formation builds up through time with the free consumption of serialized content. One free episode can elevate the likelihood of consumer purchase by up to 13%. However, as the number of free episodes consumed goes beyond a threshold, the likelihood of conversion decreases. We conclude with a discussion of managerial implications that can help content providers monetize their serialized digital content products.

Keywords: WFF pricing, habit formation, economic modeling, digital content, price design, econometric analyses

[1] Siva Viswanathan was the accepting senior editor for this paper. Guo Zhiling served as the associate editor.

Introduction

Digital content is one of the most highly consumed products on online platforms, yet the monetization of such content continues to challenge practitioners and platform operators. Despite persistent efforts by content publishers and platform operators to earn revenue from digital content, most consumers remain disinclined to pay for this type of product and instead opt to maximize benefits from free content (Berger et al., 2015). Although providing content at no charge and earning profits through alternative means (e.g., advertising-supported programs and affiliate-linking initiatives) can serve as an effective growth strategy in the short term, such initiatives are unsustainable for platform businesses in the long run (Tracy, 2020). Likewise, subscription-based service models appear to be ineffective monetization strategies for many categories of digital content, as consumers are afraid of contracts and hesitant to pay upfront and on a regular basis (Lambrecht & Misra, 2017). Correspondingly, digital platforms and content sellers are constantly seeking alternative pricing and monetizing strategies that stimulate digital content sales by building a stable revenue stream and reducing purchase barriers in the market—conditions that are necessary for maintaining healthy ecosystems on digital content platforms.

A new, innovative pricing mechanism has recently emerged in the digital content market that offers consumers the option of immediately consuming content through upfront payment or delaying their consumption by waiting and then acquiring the product for free—a pricing design that we call the "wait-for-free" (WFF) scheme. This scheme has recently been implemented by large Asian content platforms (i.e., Tencent, KakaoPage) on entertainment-oriented comic and animation sites to capture both the demand and supply sides of the platform's ecosystem. Despite the popularity of this monetization strategy in the market, however, there is limited understanding of its economic value and potential to become a legitimate pricing initiative that effectively converts free users into paying consumers, enhances user engagement, and generates stable revenue over time. To address this gap, the current study examines *whether* and *how* the emerging WFF mechanism successfully attracts new paying consumers and creates a steady cash flow cycle over time, *who* is more likely to switch from being a free-trial user to being a paying customer, and under *what* circumstances this scheme can effectively operate to drive sales over extended periods. These issues motivate the current exploration.

We direct particular attention to unraveling how consumers' unique behavioral patterns (i.e., habit formation and present bias) influence their *willingness to wait* (WTW) or *willingness to pay* (WTP) when encountering a variety of digital content entertainment products (e.g., comics, fiction, and romance) that are serialized over numerous episodes. The growing prevalence of online platforms and the increasing ubiquity afforded by various devices have dramatically increased the consumption of addictive digital content (Goovaerts, 2016). Users that frequently consume these goods have greater accumulated stocks of past consumption, which, in turn, influence their consumption patterns (Becker & Murphy, 1988). Many consumers, particularly those who find themselves at ease with spending a lot of time online, may fail to rein in their compulsive predilection for hedonic digital content (Kwon et al., 2016). These self-indulgent customers typically exhibit impatience in the consumption of such goods, attaching more weight to short-term gratification than long-term rewards. Heavy game users, for example, often prefer short-term gratification to avoid the disutility arising from deferred fulfillment. Similarly, YouTube's paying users can avail themselves of subscription services that allow them to disable advertising and watch content directly and immediately, whereas those who opt out of these offerings must endure ads to watch content. With the emergence of online markets, serialized content (e.g., fiction, comics, TV dramas) has benefitted from rising consumption, and sellers can use similar strategies to entice consumers. A story in a serialized format is usually structured over numerous episodes that build tension and end on a cliffhanger at the end of each episode to stimulate curiosity over what will happen next. Capitalizing on the dependence induced by serialized content, publishers and video-on-demand providers present consumers with the choice to wait for a few days to acquire the digital content for free or pay to enjoy it instantly.

To the best of our knowledge, this study is among the first to investigate the effects of habit formation and present bias on consumers' WTW and WTP for indulgent digital content. To derive theoretical and empirical insights into this problem, we first develop an analytical choice model that reflects the real-world decision choices of consumers in the digital content market. We draw on the habit formation framework (O'Donoghue & Rabin, 1999) to unravel how free samples of addictive digital content acquired through waiting and delayed gratification affect habit-forming behaviors that, in turn, bear on the inclination of customers to purchase content. Specifically, we theoretically explore how the WFF scheme, which exploits habit formation, performs relative to the regular pay-only alternative with respect to the monetization of addictive digital content.

The analytical derivations are then empirically validated using panel data provided by a large e-book platform that recently implemented the WFF pricing in an attempt to monetize web comics published as serialized episodes. The dataset consists of information on 6,618 individuals' choice decisions (i.e., buy or wait), which are reflected through 10,716 web comic transactions under WFF pricing. For specific empirical validations, we first carried out the structural estimation of the choice model by employing utility functions and behavioral parameters that are defined in the analytical model. We performed individual-level analyses on the basis of the random utility-based discrete choice framework (McFadden, 1974) to examine consumers' wait versus purchase decisions upon their initial entry into the market and structurally estimated the key behavioral parameters that constitute the core components of the analytical model. The results of the structural estimations corroborate the findings of the analytical derivations, reinforcing the validity of our theoretical derivations. Subsequently, we implemented various reduced-form econometric analyses to further ascertain the efficacy of the WFF scheme and shed light on the factors that influence consumers switching from free usage to paid transactions.

The empirical findings from the reduced-form analyses are also consistent with the results of the theoretical propositions. For instance, the volume of free addictive stock influences the intensity of habit formation, which, in turn, affects the willingness of consumers to pay or wait for hedonic content. In particular, WFF pricing effectively augments the WTP of low-valuation consumers as habit formation builds up through time with the free consumption of serialized content. However, as the number of free episodes consumed upon waiting goes beyond a certain threshold, the likelihood of conversion decreases. We found that 78% of consumers who initiated a purchase either upon initial market entry or upon switching continue to purchase as new episodes become available. Regarding specific economic contributions, one free episode can elevate the likelihood of consumer purchase by up to 13%, albeit the odds may vary according to content. The findings also reveal that consumers are more likely to purchase than wait with longer delays. This empirical result aligns with the analytical derivations, suggesting that consumers with a high present bias tend toward purchase more strongly than those with a low bias. Through this mechanism, the WFF design effectively creates new demand from individuals who would otherwise decline participation in the market and generates a stable revenue stream over time. With these theoretical and empirical findings as an anchor, we identified a number of valuable implications for marketers of serialized digital content with respect to effective monetization strategies.

Related Literature

Sampling and Versioning

The sampling and versioning of information goods have been widely examined as strategic initiatives that attract new consumers and affect firm revenue. These schemes commonly leverage free or low-quality products (i.e., those with only basic features or functionalities) as "bait" to foster new demand in situations that would otherwise represent a wasted opportunity. A variety of issues revolving around product sampling have been addressed in numerous studies and can be broadly categorized into two streams. The first concentrates on how product sampling influences consumer behaviors and perceptions, such as expectations regarding product quality (Goering, 1985), product and brand selection (Shiv & Nowlis, 2004), reward-seeking behaviors (Wadhwa et al., 2008), and product reviews and ratings (Lin et al., 2019). Goering (1985), for example, modeled how learning from product trials shapes expectations about product quality and found that a number of factors (e.g., the quality of a product relative to prior expectations) moderate the dynamics underlying the relationship between learning and expectations. Wadhwa et al. (2008) discovered that product sampling accompanied by a high incentive value (e.g., chocolate) encourages consumers to pursue rewards by elevating their successive consumption of related hedonic products (e.g., cola). A more recent study by Lin et al. (2019) revealed that product sampling favorably affects consumer reviews and that such evaluations are more prevalently aimed at expensive goods rather than affordable alternatives.

The second stream of research looks into the direct and indirect economic consequences of product sampling, such as brand sales (Bawa & Shoemaker, 2004), advertising revenue (Pauwels & Weiss, 2008), advertising effectiveness (Wang & Zhang, 2009), network externalities (Cheng & Tang, 2010), software licensing (Niculescu & Wu, 2014), and consumer demand for digital content (Lambrecht & Misra, 2017). Bawa and Shoemaker (2004), for instance, derived experimental evidence regarding the beneficial effects of free samples on consumer base expansion and long-term sales. According to Pauwels and Weiss (2008), however, even though some revenue can be earned through paid subscriptions, shifting from providing free content to bundling paid goods with a complementary product can cause long-term losses in advertising revenue given the possibility that subscribers to free content will leave the market. Niculescu and Wu (2014) assessed the economic value of two approaches to free software sampling (i.e., feature-limited freemium and uniform seeding) and proposed the best possible strategies for software licensing under word-of-mouth effects. Finally, Lambrecht and Misra (2017) delved into how firms that offer both free and paid content maximize profit, demonstrating the benefits of increasing the amount of free content available in periods of high demand.

Our WFF approach differs substantially from those of previous works on product sampling in several ways. In contrast to regular pay-only pricing, the WFF scheme confronts consumers with a *buy-or-wait* decision in acquiring addictive content. The sampling strategy does not offer consumers an option to wait, which can result in disutility from delayed gratification. Conversely, our WWF scheme enables consumers to make a choice between buying to derive immediate satisfaction and waiting for content to be free. Our free sample context is also unique because the magnitude of economic benefits (i.e., acquiring goods without paying) increases as consumers further delay consumption. That is, the number of free samples available under the WFF scheme increases as time progresses, thereby enabling consumers to acquire additional paid products at no charge when they defer purchase and wait for time to pass. Nonetheless, it is important to note that each consumer in our setting may also experience different levels of disutility from delayed gratification because the wait periods vary. Finally, although the majority of sampling studies have elucidated how free content can help raise profits, none of these models have entailed a direct analysis of WFF schemes as sources of revenue that exploit consumers' habit-forming tendencies and vulnerabilities to immediate gratification in the context of sequentially consumed addictive content. In conclusion, whereas the prior literature on free trials and sampling has focused primarily on how free products diminish quality uncertainties or increase network sizes for the enhancement of advertising revenues, our work concentrates on the extent to which free content affects habit formation and present bias to motivate non-paying consumers to switch to being paying customers.

In a context involving vertical product differentiation, the versioning of digital information goods has been examined as a price design that creates new demand and augments market share and revenue. Specific versioning schemes differ, but they are routinely separated into basic variants (free or low-quality products) and premium alternatives (products accompanied with additional functionalities and features). Researchers have identified the ideal tactics for deployment once version upgrades become available. Bhargava and Choudhary (2008) showed that a given versioning strategy is optimal when the highest market share gained from the sale of lower-quality product versions is greater than that obtained from the sales of high-quality alternatives. Similarly, Doğan et al. (2011) explored the effectiveness of periodic versioning strategies and found that demand variability and endogeneity determined the design of optimal software versions in each period. The works of Bhargava and Choudhary (2008) and Doğan et al. (2011) were extended by Wei and Nault (2014), who demonstrated that the price design featuring a "version-to-upgrade" deal can serve as an optimal strategy when both low- and high-quality versions are offered at the same time.

In relation to versioning and freemium strategies, neither quality variations among versions nor version upgrades are core attributes of our WFF scheme, but free content can be regarded as a "basic version" or freemium product that allows for the acquisition of paid goods as serialized digital content. Unlike the assumption adopted in the versioning and freemium literature, however, the wait option addressed in the current paper dictates the number of basic variants (e.g., free samples) offered, and content is serialized into small episodes that are addictive in nature. The central premise behind WFF pricing is that a company initially establishes prices for products to be sold to consumers with the highest WTP and then gives away the first few versions to attract consumers using a low WTP. Ultimately, this strategy is aimed at acquiring non-paying users in order to increase traffic volume and retain them for eventual conversion into paying users. This new model therefore enables publishers to simultaneously earn profits from paying consumers who are willing to pay for high-quality content and capitalize on the appeal of free content as a motivation to purchase. What separates the WFF scheme from version-based pricing is that the former centers on sales augmentation by encouraging non-paying consumers to become paying customers through the exploitation of habit formation rather than promoting match or quality values. In addition, versioning and WFF pricing may vary in terms of the nature of "free" products offered; whereas freemium products are available for free, without the need for action from consumers under versioning, earning free products through the WFF scheme necessitates a certain amount of effort—i.e., waiting—which likely accompanies disutility. Under the WFF scheme products (i.e., episodes) also become free sequentially rather than all at once via a fixed number of free samples or low-quality versions. This scheme thus differs from versioning pricing with respect to the strategic orientation and the nature of the freemium offering itself.

Habit Formation and Hyperbolic Discounting

Early economic models of addiction (e.g., Becker & Murphy, 1988) are based on the assumption of rational, time-consistent choice patterns. These models are used to analyze how forward-looking consumers who wish to maximize their intertemporal utility consume addictive products and also account for the effects of current consumption on future well-being. In opposition to the time-consistent and exponential discounting of utility, O'Donoghue and Rabin (1999) modeled individuals' lack of self-control as a time-inconsistent, present-biased preference. Present bias, represented by hyperbolic discounting preferences, was formalized theoretically by Laibson (1994), followed by O'Donoghue and Rabin (2001) and DellaVigna and Malmendier (2004), and empirically tested by Jackson and Yariv (2014) and Acland and Levy (2015).

Researchers in IS and marketing have begun to examine addictive behaviors in various online contexts. Recently, drawing on the rational addiction framework, Kwon et al. (2016) found that consumers use habit-forming mobile apps in a forward-looking manner, but individual characteristics and app types significantly moderate the nature of addictive behaviors. Schweidel and Moe (2016) established a viewing model for serialized digital content and obtained empirical evidence on how binge-watchers respond to pop-up advertisements, revealing that binge-watching is driven by the inherent traits of consumers and situational factors that are based on previously consumed content. Chen et al. (2009) investigated the effects of permanent price cuts on brand-switching behaviors in relation to addictive products among customers who rarely change brands. Their main results indicate that product cuts enable retailers of leading highly addictive products (e.g., Marlboro) to minimize market share erosion because the consumers of these goods are likely to continue consuming their preferred products, whereas those of discounted brands will likely switch to premium ones.

Consumers with inconsistent preferences over time exhibit hyperbolic discounting patterns regarding delayed rewards in that their valuation of future utilities falls more rapidly in the short run than in the long term (Ainslie, 1991; Laibson, 1997; Loewenstein & Prelec, 1992). The hyperbolic discounting framework is particularly useful for understanding the behaviors of consumers who suffer from addiction. Heavily addicted consumers discount delayed rewards more steeply than less-addicted consumers—a pattern observed in a variety of addictive product categories, including cigarettes (Cairns & van der Pol, 2000) and drugs (Bretteville-Jensen, 1999). DellaVigna and Malmendier (2004) probed the profit-maximizing contract design of several industries (e.g., gambling and credit card sectors), paying particular attention to situations in which consumers exhibit hyperbolic time-inconsistent discounting. Plambeck and Wang (2013) scrutinized how the lack of self-control among consumers affects optimal pricing and scheduling structures for services, suggesting that charging for subscriptions is an optimal strategy for maximizing revenue when customers engage in hyperbolic discounting and overestimate their capacity for self-discipline.

Our study expands the literature on habit formation and hyperbolic discounting by theoretically and empirically evaluating a new pricing structure that can positively drive the monetization of highly addictive serialized digital content. Upon demonstrating that the utilities of consumers in web comic markets feature habit formation, our analytical model illustrates how free samples of addictive content—acquired through waiting and delayed gratification—influence consumers' habit-forming behaviors, which may, in turn, affect their WTP. In particular, we identify how WFF pricing can exploit habit formation and present biasedness, respectively, to induce otherwise non-paying customers into paying customers.

Research Setting: WFF Pricing and Structures

To investigate the effects of the WFF pricing scheme on digital content sales, we obtained a unique panel dataset from a leading e-book seller in Asia (hereafter, "EcomCo"). The company also offers regularly published web comics. Each comic has a series of episodes that are released in sequential order. The total number of episodes in each comic varies across titles. Consumers have the option to wait for a certain amount of time (i.e., one week) to acquire indulgent digital content at no charge or pay to consume it immediately. Payment is made per episode, thereby compelling a purchase each time a consumer wants to proceed to the next episode without delay. The company sells two types of comics, which can be categorized on the basis of pricing schemes: WFF pricing content and regular (i.e., pay-only) content. For comics under the WFF pricing category, old episodes become free as new episodes are released on a weekly basis. Because episode updates and conversions take place weekly, the number of episodes published and the number of free episodes in a given comic increase over time. Furthermore, given the simultaneity of updating and conversion, the number of published episodes available for purchase remains unchanged in any given week.

Figure 1 shows the product page of a comic that is offered through the WFF pricing scheme. As indicated in the figure, some episodes have been switched to free content, whereas others require payment to be read. For each non-free episode, consumers are informed of the days remaining before it becomes free so that they are aware of how many days they will have to wait until episodes become available at no charge. The wait-for-free content available upon entry into the comic market varies from one to seven days because the free content conversion takes place once a week. For a given comic released under WFF pricing, the time at which an episode is converted into free content is based on release dates, with episodes released first also being converted first. The example in Figure 1 shows the five episodes of a given comic that have been released; the first two episodes have already been converted from fee-based to free content and the remaining three are still available by paid access only. Episode 3, which is the oldest episode of the three available by paid access, has one day left before it will become free. Consumers can either wait a day to read Episode 3 for free or pay to read it immediately. A new episode (Episode 6) will be released on the same day that Episode 3 becomes free.

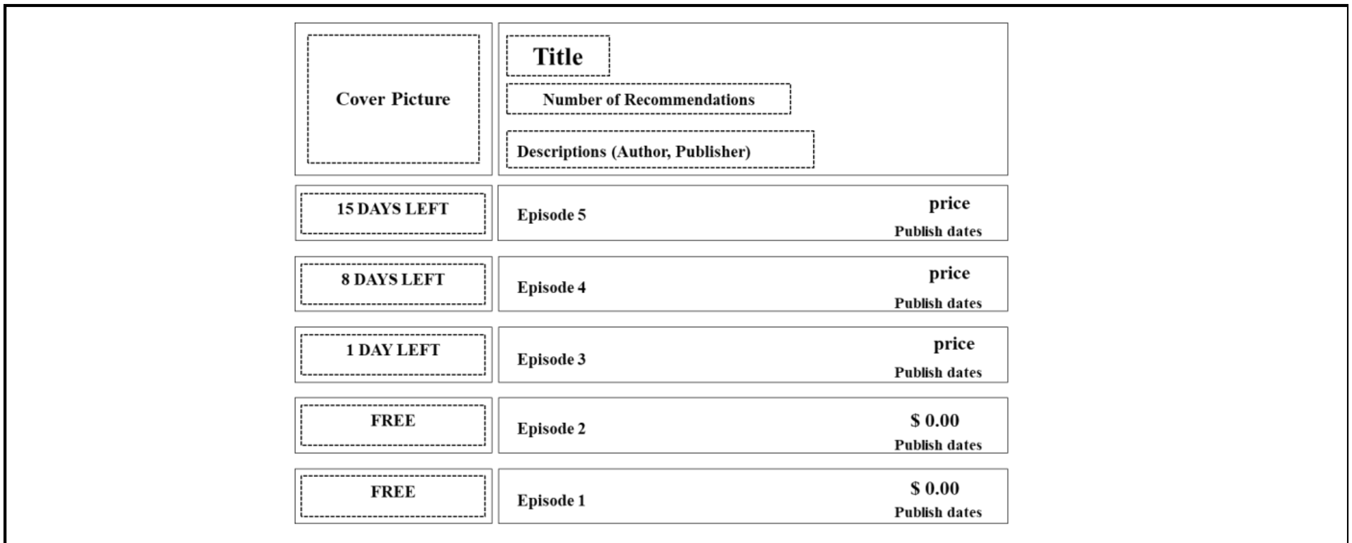

Figure 1. An Example of WFF Pricing Structure

Model

In this section, we present a decision model that illuminates the key behavioral characteristics of consumers in the web comic market described above. Any given web comic series consists of many episodes, and we assume that the price is determined by competitive pressure among platforms, causing firms to act as price-takers.[2] Firms thus aspire to maximize profit by maximizing sales volume. Using a stylized model that depicts the underlying attributes of serialized content, we examine whether the WFF pricing scheme can help increase sales beyond those generated under regular (pay-only) pricing. We show that such an increase can be enabled by exploiting (1) the addictive nature of serialized content and (2) the present-biased preferences of consumers.

We simplify how serialized web comics are offered in the real-world market as follows. In the first week's run of a particular web comic series, several sample episodes are available for free and an additional episode is released at price p. A week later, the next episode is released at the same price while the previous episode simultaneously becomes free. Subsequently, a new episode is released each week, and the oldest non-free episode becomes free.[3] Consistent with real-world observations, these episodes are presumed to be serialized in content in the sense that an episode becomes valuable only upon consumption of the previous installments.

Consider a consumer who encounters a certain web comic series at some period t, $t \in \{1,2,\ldots,T\}$. Henceforth, we denote t as the time at which a consumer enters a market for a particular web comic series. Because one episode becomes free each week, the number of episodes available for free differs, depending on when the consumer enters the market. Let f_t be the number of episodes available for free at time t. The consumer is then offered f_t free episodes as well as the most recent episode at price p. Upon sampling free episodes, the consumer entering the market recognizes that this particular series has some value $v \in [0,1]$ per episode based on their personal preferences.[4] After consuming all free episodes, the consumer can take two possible actions: buy (B) the most recent episode at price p, or wait (W) until the

[2] The prices per episode are very low, with an average price per episode of $0.24 and a maximum price of $0.35.

[3] As a consequence, there is always one episode available for purchase in the theoretical model. In reality, web comic series may start off with several episodes, some of which are free, whereas others are offered for a fee, which means that possibly more than one episode can be available for purchase at any given time in our data. The qualitative results of our theoretical model carry through even with variations in the number of initially purchasable episodes as long as the number of purchasable episodes remains steady across periods (i.e., as long as only one episode turns free each week). To be more specific, the absolute value of the threshold consumer who initiates purchase, $\hat{v}_t$, may vary according to the number of initially purchasable episodes causing a scale effect in the number of waiting consumers, but the manner in which the cohorts of waiting consumers switch from wait to purchase remains the same.

[4] We think of v as representing a consumer's preference for the overall genre, plot, or picture style of the comic. We assume that v remains constant across episodes, although it may vary slightly from one episode to another. While we maintain this assumption for analytical traceability, we do allow for v to vary in our empirical analysis. Nonetheless, if we think of v as the consumer's preference for "Game of Thrones" series, changes in v across episodes of the same series will be small relative to the variation in v comparing "Game of Thrones" to one for, say, "Friends."

episode becomes a free content in the next period.[5] Let $a_t = \{B, W\}$ be the action taken by the consumer and let c_t be the number of consumed episodes at period t. Then,

$$c_t(a_t) = \begin{cases} f_t + 1, & if \;\; a_t = B \\ f_t, & if \;\; a_t = W \end{cases} \tag{1}$$

We now proceed to subsequent periods after entry and describe how the utility function is formulated. After the initial entry period t, we denote subsequent periods as τ, for $\tau = \{t+1, t+2, \ldots, T\}$. Let k_τ be the accumulated level of consumption at period τ. The accumulated consumption level is defined recursively as $k_\tau \equiv c_\tau(a_\tau) + \gamma k_{\tau-1}$ where $\gamma \in [0,1]$ is the rate at which habit dependency decays, $k_t = c_t(a_t)$, and $c_\tau(a_\tau)$ is defined analogously to Equation (1).[6] We assume that the addictive nature of serialized content induces habit formation and that consumers therefore incur a disutility whenever they decide to wait and refrain from purchasing an available episode.[7] Specifically, a consumer incurs a disutility of $-\sigma k_\tau$ each time they forgo purchasing an available episode in period τ. Correspondingly, the consumer's instantaneous utility at time τ is:

$$u_\tau(a_\tau; k_\tau) = \begin{cases} c_\tau(a_\tau) \cdot v - p, & if \;\; a_\tau = B \\ c_\tau(a_\tau) \cdot v - \sigma k_\tau, & if \;\; a_\tau = W \end{cases} \tag{2}$$

The instantaneous utility function above exhibits habit formation in the manner defined in O'Donoghue and Rabin (1999) since the net gain from consumption,

$$u_\tau(B; k_\tau) - u_\tau(W; k_\tau) = v + \sigma k_\tau - p \tag{3}$$

increases in the accumulated stock of consumption k_τ. Parameter σ captures the strength of a product's addictive nature that magnifies the level of habit formation. Intuitively, consumers' effective WTP increases from v to $v + \sigma k_\tau$, and the larger the accumulated consumption stock, or the more addictive a product is, the greater the likelihood that they will purchase content rather than wait for it to be converted into a free product.[8]

Next, we model the intertemporal preferences of consumers. Let $U^t(u_t, u_{t+1}, \ldots, u_T)$ denote the intertemporal utility from the perspective of period t. We assume that consumers have present-biased (β, δ) preferences and that the intertemporal utility is defined as:

$$U^t(u_t, u_{t+1}, \ldots, u_T) \equiv u_t + \beta \sum_{\tau=1}^{T-t} \delta^\tau u_{t+\tau}, \tag{4}$$

where $0 \le \beta, \delta \le 1$. As usual in these models, δ represents the long-term, time-consistent discount factor, and β denotes the degree of present bias.

To cast light on a consumer's decision problem, we adopt the *perception-perfect strategy* formulated by O'Donoghue and Rabin (1999). Let $U^t(\tau)$ be the intertemporal utility of a consumer who initiates purchase at $\tau \ge t$, evaluated from the perspective of time t. When a consumer faces a decision choice between buying now and waiting for free consumption, it is conceivable to think that the initial response would be the latter because it provides a clear monetary benefit. At the same time, if a consumer buys in this period, there will be no free episode to consume in the next period, which would then compel the consumer to buy again if they were to continuously consume episodes in succeeding periods. Therefore, the consumer evaluates and compares intertemporal utilities to determine the best time to start buying, with the expectation that they will keep purchasing from then on.[9] Then, a strategy profile $\boldsymbol{a}^* \equiv (a_t^*, a_{t+1}^*, \ldots, a_T^*)$ is defined to be *perception-perfect* if for all $t < T$, $a_t^* = B$ if and only if $U^t(t) \ge U^t(\tau)$ for all $\tau > t$.[10]

[5] In our data, we observe consumers who click on an episode that has become free to consume. Thus, "wait" in our setup is "wait-and-consume-later." We do not include "leave" in a consumer's action set in order to maintain the consistency of the analytical model with the data and empirical testing. Our data show that approximately 96% of consumers who decide to remain in the market continue to consume episodes (either by purchasing or by waiting), indicating that consumers rarely "leave" in the midst of consumption.

[6] Note that $c_\tau(a_\tau)$ denotes the number of episodes consumed in period τ and follows the same definition provided in Equation (1), except that f_τ is endogenously updated dependent on the history of action profile $\{a_t, a_{t+1}, \ldots a_{\tau-1}\}$ (while f_t is given upon initial market entry). Therefore, k_τ is a stock measure of accumulated consumption whereas c_τ is a flow measure of periodic consumption at τ.

[7] Because of the disutility, one may wonder if a consumer could simply wait and not consume any free episodes until the comic series is complete so that the consumer can read everything once all episodes are out. In reality, however, most of the comics become pay-only upon completion of the series and WFF pricing is applied only to those comics that are contemporaneously being serially uploaded.

[8] Because consumers make purchase decisions before the end of the series, it is plausible to conjecture that consumers may incur disutility even when they buy all the episodes, especially when consumers find the ending unsatisfactory or when more content is not released by the platform. It is likely that such disutility also increases proportionately to the cumulative consumption stock, and it can be addressed by modifying the utility function in Equation (2). For example, a consumer may incur disutility $-\sigma k_\tau$ whenever $v_\tau < \tilde{v}$ where v_τ is the ex post realized value and $\tilde{v}$ is the ex ante expected valuation. However, because valuations are not observed in data while actions of buying and waiting are directly observed, we focus on the current utility setup.

[9] This belief system fits well with our data, which shows that only 5% of consumers who purchase web comics (either upon initial entry or upon switching) that are offered under the WFF revert back to wait-for-free consumption. Theoretically, we treat consumers who revert back to waiting as behaving off the equilibrium path. Alternatively, one may think of an opposite belief system in which a consumer expects a purchase to be a one-time event and thus anticipates reverting back to waiting. We can still construct intertemporal utilities with such belief systems in an analogous manner to what follows, but such strategies do not fit the definition of *perception-perfectness*.

[10] We used the definition of the perception-perfect strategy for *naifs* or *time-consistents*, as defined in O'Donoghue and Rabin (1999b). In their model, there

The intuition underlying the strategy is as follows. A consumer at period t evaluates their intertemporal utility from buying at period t amid the expectation that they will continue purchasing in future periods. Such utility is denoted as $U^t(t)$ and is compared with $U^t(\tau)$, which is the intertemporal utility (also evaluated from the perspective of period t) that arises from delaying purchase until some future period $\tau > t$. Upon comparison, the consumer decides to buy at period t if and only if commencing with buying now yields a higher intertemporal utility than that derived from withholding purchase until any future period $\tau > t$.

Proposition 1: *Consider consumers who enter at some period* $t \in \{1,2,\dots,T\}$ *and face the WFF pricing scheme.*

(i) *For consumers with valuations of* $v \geq \hat{v}_t(\sigma,\beta,\delta,f_t)$, *it is a perception-perfect strategy to initiate purchase upon entry:* $a_\tau^* = B$ *for* $\forall\ t \leq \tau \leq T$ *if* $v \geq \frac{p-\sigma f_t}{1-\beta\delta} \equiv \hat{v}_t(\sigma,\beta,\delta,f_t)$.

(ii) *For consumers with valuations of* $v < \hat{v}_t(\sigma,\beta,\delta,f_t)$, *it is a perception-perfect strategy to initially wait and then switch to purchase at period* $t+m$ *for* $1 \leq m \leq T-t$: $a_\tau^* = W$ *for* $t \leq \tau < t+m$ *and* $a_\tau^* = B$ *for* $t+m \leq \tau \leq T$ *if* $v \geq \frac{p-\sigma(\sum_{\tau=0}^{m-1}\gamma^\tau + f_t\gamma^m)}{1-\beta\delta} \equiv \hat{v}_{t+m}(\sigma,\beta,\delta,\gamma,f_t)$.

Detailed proofs of all propositions and corollaries are provided in Appendix A. Note that when $\sigma = 0$ so that there is no habit formation, consumers with valuations of $v \geq \frac{p}{1-\beta\delta}$ will purchase an episode in each period, and this proportion will stay consistent regardless of how long a consumer has participated in this market. However, when $\sigma > 0$, the proposition indicates that, in each period after *t*, there is a cohort of paying consumers who transition from waiting for free conversion to purchasing for immediate gratification. For example, consumers with valuations of $v \in [\hat{v}_{t+1}(\sigma,\beta,\delta,\gamma,f_t), \hat{v}_t(\sigma,\beta,\delta,f_t)]$ switch to buying in period $t+1$, and then consumers with valuations $v \in [\hat{v}_{t+2}(\sigma,\beta,\delta,\gamma,f_t), \hat{v}_{t+1}(\sigma,\beta,\delta,\gamma,f_t)]$ switch in period $t+2$, and so on. Such conversions occur as the accumulated stock of free episodes that were acquired by waiting increases the WTP of low-valuation consumers. Figure 2 illustrates how the purchase behaviors of consumers evolve as time progresses.

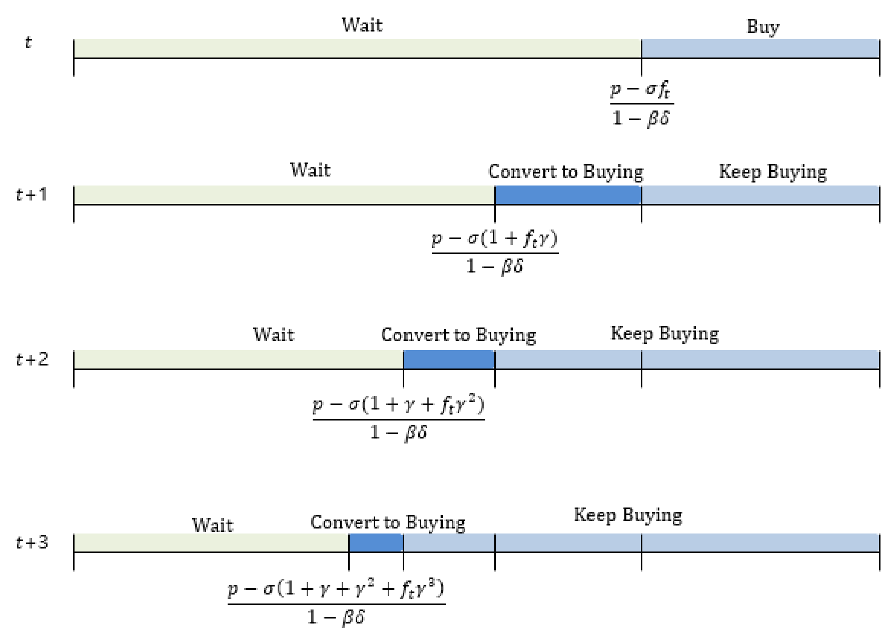

Figure 2. Purchasing/Waiting Behaviors of Consumers Who Enter at *t*

are naive, time-consistent, and sophisticated consumers. The definitions of naive and time-consistent consumers are the same except that $\beta < 1$ for *naifs* whereas $\beta = 1$ for time-consistent consumers. Sophisticated consumers are described in a different fashion, but we could not distinguish them from naive customers in our data.

Given the results in Proposition 1, we can derive the following comparative statics on the changes in a consumer's consumption behavior as the key behavioral parameters of the model vary.

Corollary 1: *The comparative statics on* $\hat{v}_t(\sigma,\beta,\delta,f_t)$ *and* $\hat{v}_{t+m}(\sigma,\beta,\delta,\gamma,f_t)$ *suggest the following:*

(i) *The probability that a consumer immediately initiates purchase upon entry increases in* σ *and* f_t *(measures of habit formation) and decreases in* β *(measure of present biasedness).*

(ii) *The probability that a consumer who has been waiting for free consumption until day* $t+m-1$ *will switch to buy at period* $t+m$ *increases in* σ, f_t, γ, *and m (measures of habit formation) and decreases in* β *(measure of present biasedness).*

The comparative statics provide an intuitive result that consumers tend to lean toward buying instead of waiting when habit formation (either σ or γ increases) and immediacy bias become stronger (β decreases). In addition, we can confirm that the cumulative time spent on the platform consuming free episodes (*m* increases) increases the likelihood of consumers switching.

It may be questioned how these changes in consumption behavior compare to purchase patterns under the pay-only pricing scheme, in which several initial episodes are available for free for sampling purposes and all the remaining releases are available for purchase only at price *p*. Let $\overline{f}$ be the number of free sample episodes. A new episode is released weekly just as before, but unlike the WFF, the number of free episodes stays fixed at $\overline{f}$ while the number of purchasable episodes accrues as time passes. That is, a consumer who encounters a web comic at some time $t, t\in\{1,2,\ldots,T\}$ finds t number of episodes available for purchase. Under this pay-only scheme, the consumer either "buys" (*B*) or "does not buy" (*N*) the available episodes. Waiting an additional week does not change the consumer's viewing options in the sense that the number of available free episodes remains the same, while the number of purchasable episodes accrues over time. Under the pay-only scheme, the perception-perfect strategy of a consumer changes as follows.

Proposition 2: *Consider consumers who enter at some period* $t\in\{1,2,\ldots,T\}$ *and face the pay-only pricing scheme.*

(i) *For consumers with valuations of* $v\geq\hat{v}_t^P(\sigma,\beta,\delta,\bar{f})$*, it is a perception-perfect strategy to initiate purchase upon entry:* $a_\tau^{P*}=B$ for $\forall\, t\leq\tau\leq \mathrm{T}$ *if* $v\geq p-\frac{\sigma\bar{f}}{(1-\beta\delta)t}\equiv\hat{v}_t^P(\sigma,\beta,\delta,\bar{f})$.

(ii) *For consumers with valuations of* $v<\hat{v}_t^P(\delta,\beta,\sigma,\bar{f})$*, it is a perception-perfect strategy to not purchase:* $a_\tau^{P*}=N$ for $\forall\, t\leq\tau\leq \mathrm{T}$ *if* $v<\hat{v}_t^P(\delta,\beta,\sigma,\bar{f})$.

It is worth highlighting several interesting features of the above result. First, if web series do not induce habit formation so that $\sigma=0$, then the standard rational result arises where only consumers who have valuations higher than the price purchase the product, i.e., $\hat{v}_t^P(\sigma,\beta,\delta,\bar{f})=p$ when $\sigma=0$. Thus, we can conclude that habit formation induces more consumers to purchase even under the pay-only scheme since $\hat{v}_t^P(\sigma,\beta,\delta,\bar{f})\leq p$ and $\frac{\partial\hat{v}_t^P(\sigma,\beta,\delta,\bar{f})}{\partial\sigma}<0$. Second, a consumer is less likely to initiate purchase when they encounter the web series after much time has passed, as can be seen from the comparative statics $\frac{\partial\hat{v}_t^P(\sigma,\beta,\delta,\bar{f})}{\partial t}>0$. Third, consumers do not exhibit switching behavior under the pay-only scheme. This is because "waiting" only increases the number of episodes that the consumer must buy without yielding any further free episodes. Thus, if a consumer decides not to make a purchase initially, there is no reason for a consumer to switch to buying in any subsequent periods.

We can compare the difference in consumer behaviors under the pay-only and the WFF pricing schemes using the threshold valuations $\hat{v}_t^P(\sigma,\beta,\delta,\bar{f})$ and $\hat{v}_t(\sigma,\beta,\delta,f_t)$, the cut-off valuations that induce consumers to initiate purchase upon entry under the pay-only and WFF schemes, respectively.

Corollary 2: *Let* $\hat{t}$ *be the value such that* $\hat{v}_{\hat{t}}^P(\sigma,\beta,\delta,\bar{f})=\hat{v}_{\hat{t}}(\sigma,\beta,\delta,f_t)$ *. Then, for* $\forall t<\hat{t}$ *,* $\hat{v}^P(\delta,\beta,\sigma,t,\bar{f})<\hat{v}(\delta,\beta,\sigma)$ *while* $\hat{v}^P(\delta,\beta,\sigma,t,\bar{f})\geq\hat{v}(\delta,\beta,\sigma)$ *for* $\forall t\geq\hat{t}$.

The corollary implies that, holding constant the population of newly entering consumers, more consumers purchase upon entry under the pay-only scheme at the early stages after the initial release of a web comic series. However, the likelihood of initial purchase eventually reverses as time passes and more free episodes accumulate under the WFF scheme. This result signifies the effectiveness of WFF pricing over pay-only pricing wherein the WFF pricing successfully induces otherwise non-purchasing consumers to make purchases through habit formation. We now move onto the next section, which provides empirical insights into these analytical findings.

Data and Variable Descriptions

Our dataset comprises 31 weeks of information on individual transactions involving the acquisition of web comics under WFF pricing that were available for sale between August 2015 and March 2016. The data enabled us to determine the purchase behaviors and preferences of consumers regarding the WFF pricing design. Because each comic narrative unfolds through a number of regularly published (e.g., weekly) episodes, consumers may visit the product pages of web comics periodically in a given week to purchase a newly issued installment. For example, a consumer may purchase an episode of web comic title A at week t and revisit the product page at week $t+1$ to buy a newly released installment. Thus, we tracked the series of transactions made by each consumer for a given comic to examine the consumer's habit-forming behaviors stimulated by the acquisition of addictive stocks. In addition to exploring purchase data, we obtained free episode acquisition data from the company's log files, which document the cookies that are deployed to track each consumer's online activity. These data allowed us to accurately evaluate how the consumption of free episodes stimulates habit formation and present-biased behaviors. The greater the number of episodes consumed, the higher the degree of impatience that may compel the purchase of subsequent episodes.

As shown in the analytical modeling from the previous section, we examined the purchase decision of consumers in two scenarios: immediate purchase upon initial entry into the market and switching from waiting to purchasing. The decision of consumers to buy a product upon first entry into the market is not a motive-free act but one carried out after the consumption of episodes that had already been converted into free stocks before market participation. The choice to wait earns them the opportunity to consume more free episodes and may encourage purchase at a later time.

To disentangle the dynamics of the two purchase occasions (i.e., purchase upon entry and purchase after waiting), we separately recorded the number of free episode stocks consumed by each consumer upon initial entry into the market ($InitialFree$) and the accumulated number of free episodes made available to each customer through waiting ($AccumulateFree$). The stocks consumed by a customer on entry and after waiting are denoted as f_t and m in our analytical model, respectively. Because one episode turns into a free product every week, consumers who wait longer to acquire a given comic are more likely to consume an increasing accumulation of free episodes (i.e., m).[11] We also noted the remaining days until conversion to free content ($DaysRemain$), which is measured by the number of days left for the oldest episode to be converted into free content from the time a consumer enters the market. The longer that consumers wait to access free content, the greater the disutility they may experience. Put differently, patient consumers (i.e., less present biased) may be more willing to wait longer for free consumption than impatient consumers. Thus, the number of days until an episode becomes free is an indication of the consumer's present biasedness because it captures how delays affect the consumer's purchase intentions.

We acquired data on consumers' product page views from the company's log files to pinpoint when consumers decide to wait for free content. We likewise collected data on the time of the page request and obtained the unique identification number attached to each comic. The comic identification number provides information important to identifying consumers who consume WFF items. We also acquired additional data regarding comic characteristics and the number of recommendations that other customers gave each comic. In our empirical setting, the number of recommendations is similar to the "like" function on Instagram or Facebook, with consumers endorsing a given web comic. This variable is displayed on a detailed product page together with other product-related information. The number of "likes" on social media sites has been used in engagement metrics (Lee et al., 2018)—more such approval signals on posts indicate greater engagement among readers. Yang et al. (2019) asserted that the pattern of liking behavior reflects positive, affirmative emotions such as agreement, empathy, acceptance, or awareness. Similarly, the number of recommendations points to the positive emotions of consumers who want to endorse a product, thereby serving as an index of product quality (Zhu & Zhang, 2010). Finally, we acquired information on product characteristics, such as the number of episodes available for purchase, sales price, and product category (adult only vs. general), as well as consumer-specific information, such as age and gender. The final dataset contained data on 6,618 individuals who engaged in 10,716 web comic transactions under WFF pricing. Table 1 presents the descriptive statistics of the key variables.

Empirical Validation

To explore how habit formation and present bias affect the choice of individuals to use the WFF scheme, we analyzed three dimensions of the focal issues: (1) wait-versus-purchase decisions of consumers who are just entering the market, (2) the performance of the WFF scheme compared to that of the regular pay-only option, and (3) consumers' switching behaviors arising from habit formation and present bias. The first issue was addressed by conducting structural estimation based on the random-utility-based discrete choice framework to corroborate the key analytical derivations in Corollary 1(i) and validate the effects of habit formation on decisions revolving around waiting or purchasing.

[11] Some consumers may strategically delay consumption to stockpile free episodes and consume them at once. Our data reveals that the majority of consumers who wait for conversion into free content enter the market every week to consume free episodes.

Table 1. Variable Descriptions and Descriptive Statistics

Variables	Description	Mean	*SD*	Min	Max
InitialFree	The number of free episodes consumed by consumer (i) for a given comic (j) upon first entry into the detailed page of the comic	5.507	5.231	1	29
AccumulateFree	The number of accumulated free episodes consumed by consumer (i) for a given comic (j) upon waiting for free conversion at the t^{th} purchase session.	28.349	7.219	3	32
DaysRemain	The number of days remaining until a given comic (j) episode turns free when consumer (i) enters the market	3.826	2.573	1	7
PayEp	The number of episodes available for purchase in a given comic (j) when consumer (i) enters the market	18.705	18.700	1	192
Recommend	The number of recommendations given to a comic (j) when consumer (i) enters the market. This value is normalized by the number of consumers who read each comic.	0.394	0.852	0	0.955
SNS_Recommend	The number of recommendations given to a comic (j) on SNS when consumer (i) enters the market. This value is normalized by the number of consumers who read each comic.	0.198	0.741	0	0.701
Price (USD)	Sales price charged to an episode of a given comic (j)	0.240	0.106	0.091	0.351
Adult	A binary variable indicating whether a comic (j) belongs to an adult category	0.126	0.343	0	1
Age	Age of consumer (i)	28.553	11.965	8	93
Gender	Consumer gender (i) 0: Male, 1: Female	0.582	0.494	0	1

This structural approach unravels how the availability of free episodes influences the accumulation of addictive stocks and hence the predisposition toward habit formation. This accumulation and predisposition, in turn, affects consumers' decisions to wait for free episodes or immediately purchase them for instant gratification. In addition, we extended our analyses by showing how individual consumers would strategically behave under the two pricing options in order to provide empirical insights into Corollary 2.[12] Lastly, the third dimension was explored using reduced-form econometrics to flexibly examine the switch from non-paid to paid goods and assess the performance of the WFF mechanism. Specifically, Corollary 1(ii), was assessed by leveraging a proportional hazard model in scrutinizing switching patterns and identifying the moderating factors for conversion into paying consumers. To reinforce the validity of our findings, we undertook a number of robustness procedures.

Wait versus Purchase Decisions

We used the random-utility-based discrete choice framework (McFadden, 1974) to examine consumers' wait-or-purchase decisions upon first entry into the market. To validate the theoretical prediction regarding the effects of habit formation on initial purchase, we restricted our attention to completely present-biased consumers ($\beta = 0$).[13] To complement our parsimonious approaches, we carried out an analysis to comprehend individuals' switching behaviors without imposing restrictions on β (see the following section).

[12] Note that our analytical derivations are designed to reflect individual consumers' strategic behaviors in the presence of alternative paying options rather than to directly estimate sales variations over time, which require many assumptions. Nevertheless, sales patterns at the product level under the two pricing mechanisms can hint at the efficacy of these options while providing managers with valuable implications regarding the enhancement of monetization strategies.

[13] When we proposed the assumption that the value of β is non-zero, an essential task would be to look into the lifecycles of individuals, as reflected in Equation (4). Under this situation, we would have to estimate dynamic discrete choice models with hyperbolic discounting, which would necessitate the estimations of not only β but also γ and δ. A simultaneous structural estimation of β and δ has been known to be an excessively challenging issue. Fang and Wang (2015) attempted to estimate the parameters in question by means of exclusion restrictions. Unfortunately, this method is not easy to implement in our setting given the lack of access to the exclusion restrictions imposed by Fang and Wang (2015). Moreover, Abbring and Daljord (2020) recently raised major concerns regarding the identification approaches proposed by Fang and Wang (2015), again demonstrating the challenging nature of structural estimations of dynamic discrete choice models with hyperbolic discounting as econometric problems.

Consider consumer[14] i who starts to read web comic j. Upon initial entry into the market, the stock of addiction (k_{ij}) is equal to the number of free episodes consumed (f_{ij}), which varies across individuals given differences in market entry timing. In the theoretical model, consumers decide to purchase an episode if $u(B; f_{ij}) - u(W; f_{ij}) = (v_{ij} + \sigma f_{ij} - p_j) > 0$. Note that we cannot perfectly observe the random utility (v_{ij}) specific to individual comics, but instead observe a vector of variables (x_{ij}) that are correlated with v_{ij}. Specifically, we assume that $v_{ij} = \theta' x_{ij} + \epsilon_{ij}$ where ϵ_{ij} is an i.i.d. idiosyncratic error that follows a standard normal distribution. Under this condition, the random utility of consumers can be written as $U_{ij} = u(B; f_{ij}) - u(W; f_{ij}) = \sigma f_{ij} - p_j + \theta' x_{ij} + \epsilon_{ij}$. Because the scale of the utility is not identified, we multiply α with price and normalize the variance ϵ_{ij}. Thus, the final random utility can be expressed as $U_{ij} = \sigma f_{ij} - \alpha p_j + \theta' x_{ij} + \epsilon_{ij}$, where x_{ij} includes an individual-specific control ($Gender$) and various web comic-specific controls, such as whether content belongs to the adult category ($Adult$), the number of episodes available for purchase ($PayEp$), and the number of recommendations offered by other consumers in EcomCo's platform ($Recommend$) and social media sites ($SNS\_Recommend$).

In addition, consumer i may encounter different days remaining until the oldest available paid episode is converted into a free episode. Given these differences, consumers may hold off purchasing until they can obtain the episode for free or buy the episode instantly, depending on their degree of present-biased time preference. We incorporated $DaysRemain$ into our model to investigate how delayed free consumption would affect consumers' purchase decisions. It should be noted that the number of free episodes consumed ($InitialFree$) may be endogenous given the omitted variables that are jointly correlated with consumers' decision to purchase a product. Individuals who are more intrigued by a certain comic may consume more episodes that are available for free—a behavior that potentially induces purchase. We therefore employed an instrumental variable (IV) to alleviate potential endogeneity issues: a consumer *i*'s historical consumption of free episodes ($HistFreeConsump$). Detailed explanations about the adoption of this IV are available in Appendix B.

Table 2 shows the structural estimation results on the wait-versus-purchase decisions of consumers taking diverse customer characteristics into account. All the parameters are precisely estimated with predicted signs. With respect to the effects of the number of free episodes consumed by each consumer, the estimated coefficient of $InitialFree$ (σ) is positive (0.123) and significant at the 0.01 level, indicating that consumers are more likely to purchase as the number of free episodes increases. The results corroborate *Corollary 1-(i)*. Also, the estimated coefficient of $Price$ (α) is positive (0.001) and significant at the 0.01 level; therefore, the impact of price (- α) on purchasing is negative, indicating a downward-sloping demand curve.

However, the estimated coefficients of θ reflect that wait-or-purchase decisions vary significantly contingent on a consumer's demographic characteristics ($Gender$) and the genre of an available web comic ($Adult$). The results indicate that female consumers are inclined to purchase paid episodes rather than wait for free options. Adult content attracts fewer purchases than waits compared with non-adult counterparts. The estimate of $DaysRemain$ is positive (0.269) and significant at the 0.01 level, reflecting that consumers tend to purchase rather than wait because the long interval between instant consumption and the availability of free episodes discourages the latter choice. This trend is indicative of the present-biased nature of consumers—the utility of deferring decreases as the period of delay increases. The number of payable episodes negatively affects (-0.022) a consumer's propensity to purchase. The estimates of both $Recommend$ and $SNS\_Recommend$ are positive (0.097 and 0.085, respectively) and significant at the 0.01 level, suggesting that consumers tend to purchase comics that are highly recommended by other customers.

We quantified the economic impact of the number of free episodes on purchase decisions by using an odds ratio. For consumers just entering the WFF market, one giveaway episode can yield as much as a 13% increase in the odds that they will purchase the next available paid episode, with all other components held constant.[15] Figure 3 compares the estimated and predicted probability of initial purchase as a function of the number of free episodes. The fit of our baseline model to the data is reasonably close and captures the overall pattern of increase. To highlight the importance of parameter σ in explaining the rising pattern in the data, we also estimated the model by restricting the value of σ to zero. The results confirm that the model cannot generate an increasing pattern without the positive effect of habit formation.

[14] Consumers may selectively consume comics under either pay-only or WFF pricing schemes on the basis of their preferences and price sensitivity levels, which may give rise to potential selection biases. To address the issue surrounding unobserved consumer preferences and characteristics that may be correlated with the selection of different pricing options, we identified consumers who read comics under both schemes at least once. The individual-level transactional and browsing data enabled us to determine purchase behaviors and preferences for different pricing structures.

[15] We computed the threshold number of paid episodes that publishers can take to benefit from WFF markets (refer to Appendix C for more details).

Table 2. Estimated Results for Consumers' Wait vs. Purchase Decision

Parameter	Variables	Estimate	*SE*
σ	InitialFree	0.123***	(0.004)
α	Price	0.001***	(0.000)
θ	Gender	0.144***	(0.029)
	Adult	-0.137**	(0.665)
	DaysRemain	0.269***	(0.006)
	PayEp	-0.022**	(0.007)
	Recommend	0.097***	(0.020)
	SNS_Recommend	0.085***	(0.014)
	Constant	-1.735***	(0.135)
Observations	10,716		

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

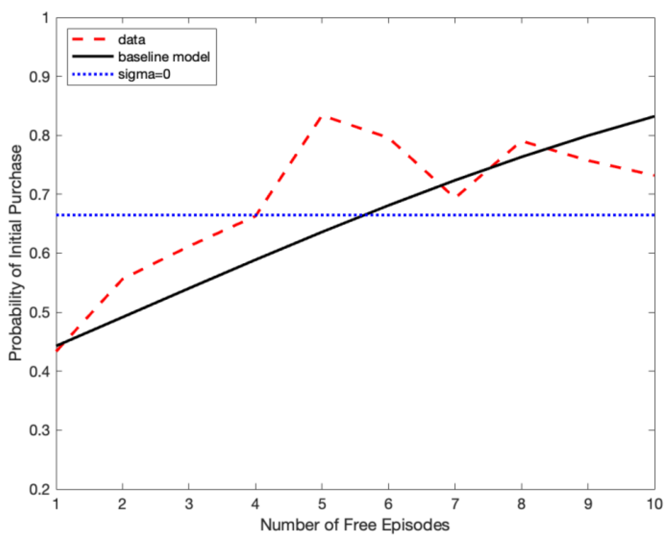

Figure 3. Testing Model Fit

With the estimated parameters, we tested Corollary 1(i) and Corollary 2 by quantifying how a representative consumer behaves with different numbers of free episodes (f_{ij}) under both wait-for-free and pay-only schemes. We calculated the purchase probability for a representative consumer and comic by assuming average values of x_{ij} and p_j denoted by $\bar{x}$ and $\bar{p}$. The probability of initial purchase under WFF and pay-only pricing can be calculated as $Pr(\epsilon_{ij} > -\theta'\bar{x} - \sigma f_{ij} + \alpha\bar{p}) = 1 - \Phi(-\theta'\bar{x} - \sigma f_{ij} + \alpha\bar{p}) = \Phi(\theta'\bar{x}\,\sigma f_{ij} - \alpha\bar{p})$, where Φ is the CDF of standard normal distribution. Under WFF pricing, the number of initial free episodes (f_{ij}) is given by $f_{ij} = t$ where $t = 1, \ldots, T$. Conversely, under the pay-only scheme, f_{ij} is fixed. We set $f_{ij} = 4$ on the basis of the average number of free episodes for comics sold under pay-only pricing.

Figure 4 shows that the probability of initial purchase under WFF pricing increases as time goes on after the initiation of a comic, as predicted by Corollary 1(i). The same probability decreases under pay-only pricing, as expected by Corollary 2. The likelihood drops because consumers are required to purchase an increasing number of episodes but have access to only a fixed number of free episodes. Accordingly, the number of free episodes per paid episode decreases. These two probabilities are (exactly) the same in the second week. Consumers entering the market in the second week can read two free episodes under WFF pricing and then need to decide whether to purchase one paid episode. However, under the pay-only pricing scheme, consumers can read four free episodes but then need to decide whether to purchase two episodes. Effectively then, consumers acquire two free episodes for each paid installment.

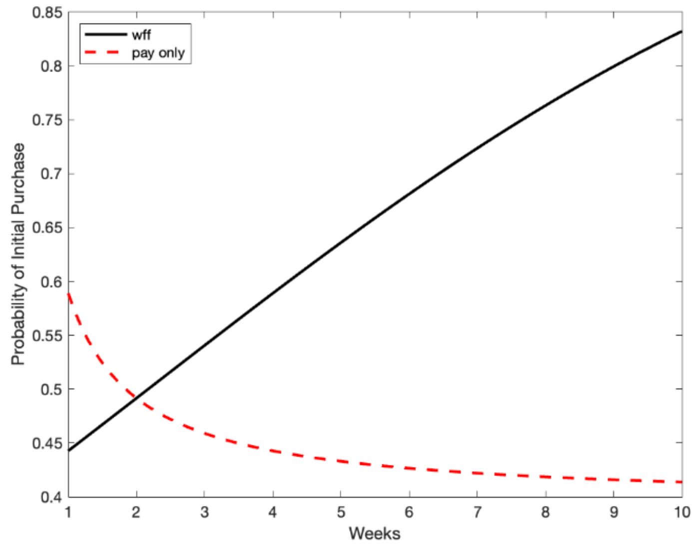

Figure 4. Fraction of Initial Purchase under WFF and Pay-Only Schemes

Consumers' Switching Behaviors Due to Habit Formation

We next tested Corollary 1(ii) by examining a consumer's decision to become a paying customer from the initial stages of free episode consumption while the habit-forming consumption of paid content decays. As shown in the analytical derivation, another source of increase in the sale of web comics through WFF pricing is the gradual rise in the WTP fostered by the habit-forming consumption of free content over time. In the switching decision, habit formation occurs owing to m. We incorporate the time-varying effects of f_t ($InitialFree$) and m ($AccumulateFree$) into the model to reflect addiction decays.

Consumers who engage in such switching purchases initially wait for free content but decide in subsequent periods to pay for immediate consumption as their accumulated stocks of free content increase. Our dataset contained 3,190 unique consumers and 5,983 observations, encompassing both the switching and waiting events of individuals. To explore the salient aspect of switching behaviors on the basis of observational data, we performed survival analysis and accordingly modeled and scrutinized such behavioral patterns in relation to habit-forming stocks (i.e., the consumption of free episodes once individuals opt for waiting). Given that the switch from non-paying to paying consumers can be viewed as an event, survival analysis, which involves inquiring into the expected duration until the occurrence of an event of interest (i.e., conversion), is well suited for the exploration of switching behaviors.

We used the extended Cox model characterized by shared frailty (Kleinbaum, 1998) to reflect right censoring in our data and time-varying covariates in our model (Scherer et al., 2015).[16] Cox regression enabled us to account for the influence of truncation and censoring problems (Hosmer & Lemeshow, 1999). The proportional hazard model enables researchers to leave underlying survival functions unspecified while still deriving accurate results. In our dataset, each observation is considered an at-risk event following consumers switching from waiting to buying at some time t_0. If a consumer decides to engage in such switching, the event is regarded as "failed" at time t. We incorporated time-varying covariates into our model to examine the dynamic effects of variables on survival time.[17] In this regard, we specify our proportional hazard model as follows:

$$h_i(t, X) = h_0(t)\exp(\eta X),$$

where $h_0(t)$ describes the baseline hazard function at time t, and ηX shows the effects of covariates X. Covariates

[16] A concern that often arises in survival analysis is censoring, which occurs because the commencement and conclusion of some observations cannot be identified. Although our dataset was right-censored, more than 75% of the comic samples in our dataset were completed within our dataset period (31 weeks), suggesting that the majority of the observations did not suffer from the censoring problem.

[17] To test the independence of X from survival time, we conducted a Schoenfeld residual test (Grambsch and Therneau, 1994), which suggested that $AccumulateFree$, $AccumulateFree^2$, and $InitialFree$ violate the core assumption (Table D in Appendix D).

X encompasses product- and consumer-specific characteristics—namely, the number of accumulated episodes consumed by consumers upon waiting, the number of free episodes consumed at the time consumers first enter a specific web comic market, the number of remaining days, the number of available pay episodes, the number of recommendations a comic receives on the EcomCo platform and SNS, the price of a comic, whether the comic belongs to the adult category, and users' ages and genders (Details of the survival model are available in Appendix D). We also inquired into the unobserved heterogeneity shared by individual consumers belonging to each web comic group. In the survival analysis, frailty is analogous to latent random effects, for which within-group correlation was considered in our model. The modeling conducted in this work allows individual consumers within each web comic group to share the same level of frailty, although unobserved heterogeneity may be common to all web comic groups. The hazard model that is incorporated with shared frailty (λ_j) can be specified as:

$$h_i(t|\lambda_j, X) = h_0(t)\lambda_j \exp(\eta X)$$

$$\eta X = \eta_1 AccumulateFree_{ijt} + \eta_2 AccumulateFree_{ijt}^2 + \eta_3 InitialFree_{ij} + \eta_4 PayEp_{ij} + \eta_5 DayRemain_{ij} + \eta_6 Recommend_{ij} + \eta_7 SNS\_Recommend_{ij} + \eta_8 Adult_j + \eta_9 price_j + \eta_{10} Age_i + \eta_{11} Gender_i + \varepsilon_{ij}, \quad (5)$$

where λ_j denotes the shared frailty of consumers (i) across a web comic (j), which is assumed to be gamma distributed with a mean value equal to 1 and a variance equal to ω. The estimated results of the extended Cox hazard model are presented in Table 3. The findings show that $AccumulateFree$ exhibits a nonlinear relationship with the hazard that comes with switching behavior, implying that the risk of accompanying the shift from waiting to buying increases with the number of free episodes consumed while waiting but eventually decreases when the number of free episodes exceeds certain thresholds. We also probed time-varying effects (TVE) in relation to $AccumulateFree$ and its squared term. Here, the effects of the number of free episodes consumed when waiting (i.e., habit-forming stocks of web comics) are amplified over time. The estimation results for TVEs are also provided in Table 3. As reflected in the table, the effects of $AccumulateFree$ (0.068) are strengthened as time progresses, implying that the impact of habit-forming stocks becomes prominent over time. The estimated coefficient of $InitialFree$ (0.489) is positive and statistically significant at the 0.01 level, suggesting that the risk of shifting from waiting to purchasing increases with the number of free episodes consumed upon first market entry for each specific comic. However, this positive effect diminishes over time (-0.077), which may indicate the decay of habit formation owing to the consumption of free episodes upon initial market entry.

Table 3. Estimated Results for Survival Analyses on Switching Behavior

Variables	**Main effect**
AccumulateFree	0.196*** (0.019)
AccumulateFree_sq	-0.007*** (0.001)
InitialFree	0.489*** (0.046)
DayRemain	0.049***(0.011)
PayEp	-0.037* (0.019)
Recommend	0.781*** (0.220)
SNS_Recommend	0.415** (0.0970)
Adult	-0.352 (0.410)
Price	0.001 (0.002)
Age	-0.006 (0.004)
Gender	0.041 (0.059)
TVE	
AccumulateFree	0.068 *** (0.011)
AccumulateFree_sq	-0.001 (0.001)
InitialFree	-0.077***(0.012)
Observations	5,983
Log-likelihood	-8741.164
AIC	13956.74

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Robustness Checks

We conducted a number of robustness procedures to ensure the accuracy of our estimation approaches and findings.

Alternative to the number of free episodes consumed: We found a positive effect on immediate purchase from the consumption of free episodes upon initial market entry. We conducted a robustness check to substantiate the effects of free episodes by employing an alternative variable, namely the number of available free episodes when a consumer i enters each comic market ($FreeEpAvailable$). This variable is an exogenous factor of a consumer's decision to consume episodes at no charge since the number of available free episodes across all comics increases by one each week. We utilized the IV probit model to corroborate our findings in the "Wait versus Purchase Decisions" section. The results are presented in Table 4. The estimated coefficient of $FreeEpAvailable$ is positive (0.312) and significant at the 0.01 level, indicating that consumers are more likely to purchase as the number of free episodes increases. This result corresponds with those of our main analyses, corroborating the positive effect of the number of free episodes on the monetization of content.

Evidence regarding the use of perception-perfect strategies: As noted in the analytical model, consumers make purchase decisions on the basis of a *perception-perfect strategy*, wherein they evaluate the intertemporal utility presented by the period at which they enter the market with the expectation that they will continue to buy products from then on. We validated this mechanism in terms of purchase retention on the basis of our dataset. Purchase retention for a given comic signifies the use of the perception-perfect strategy, in which consumers keep buying newly released episodes until the end of the series. The statistics of purchase retention (either upon first entry into the market or upon switching) in a WFF setting show that more than 78% of consumers who initiate purchase either upon initial market entry or upon switching continue to purchase as new episodes become available. These consumers return to the platform to purchase freshly released episodes and completely consume available ones.

Robustness checks for alternative explanations of habit formation: Although plausible in general, the outcomes of free consumption may give rise to sampling effects, which enable consumers to ascertain product quality before making a purchase. We thus conducted robustness checks to rule out alternative explanations of the effects of free episodes. First, we interacted $InitialFree$ and $DaysRemain$ to ascertain the differential impact exerted by the number of free episodes on the effect of the remaining days until episodes became free. According to O'Donoghue and Rabin (2001), habit formation leads individuals to continue consuming products because refraining from doing so is a "painful" alternative. Consequently, a high degree of present-biased preference induces considerable habit formation, triggering impatience associated with delayed fulfillment. The positive and significant coefficient of an interaction term points to the occurrence of habit formation, wherein consumers become increasingly intolerant of waiting as they consume more free episodes.

The findings in Table 5 demonstrate that the interaction between $InitialFree$ and $DaysRemain$ (0.007) is positive and significant at 0.05 level, implying that consumers are more predisposed toward buying for instant consumption, as the level of present-biased preference is magnified with the degree of habit formation. That is, consumers become more impatient and reluctant to endure delayed gratification as the number of episodes they have consumed accumulates.

In addition, we tested the sampling effects of free episodes by examining whether exposure to these items drives purchasing. We restricted the sample in the robustness check to comics offered under the regular pricing scheme to control for factors that may generate habit formation. Under this scheme, the number of episodes available for free is fixed at four throughout a product's life cycle. We employed $FreeEpView$ which is a binary variable that is coded as 1 if a consumer is exposed to free episodes prior to purchase. We closely followed the model specification and estimation of Choi et al. (2019). The results are presented in Table 6. The estimated coefficient of $FreeEpView$ is statistically insignificant, suggesting that consumers' purchase of comics is unaffected by whether they read the three free episodes first. This finding serves as empirical evidence that the sampling effects of free episodes are not significant and that such influence cannot be generalized to our empirical setting.

Product-level analysis: In earlier sections, we showed both analytically and empirically how individuals would strategically behave under the two pricing options. To provide further insights, we empirically examined the economic benefits of WFF pricing by comparing its effectiveness with that of the pay-only scheme using *product-level* sales data on comics offered under both pricing strategies. A noteworthy issue is that products available through WFF pricing may have different observed and unobserved product-specific characteristics compared with those offered via pay-only pricing. Consequently, the differences in sales between WFF and pay-only products may be attributed to the presence of exogenous factors that may affect sales. We resolved this issue through a series of matching techniques (Tables E1 and E2 in Appendix E).

Table 4. Robustness Check for Consumers' Wait vs. Purchase Decision

Variables	Purchase
FreeEpAvailable	0.312*** (0.011)
Price	-0.023*** (0.004)
Gender	0.393*** (0.062)
Adult	-0.194*** (0.052)
DaysRemain	0.510*** (0.014)
PayEp	-0.023** (0.014)
Recommend	0.551*** (0.031)
SNS_Recommend	0.190*** (0.016)
Constant	-1.792*** (0.288)
Observations	10,716

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5. Interaction Effects between the Number of Free Episodes Consumed and the Remaining Days until Conversion to Free Content

Variables	Purchase
$InitialFree$	0.113*** (0.023)
$DaysRemain$	0.556*** (0.043)
$InitialFree * DaysRemain$	0.007** (0.003)
Control	YES
Constant	-4.495*** (0.322)
Observations	10,716

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 6. Estimated Results for the Effect of Quality Assurance of Free Episodes

Variables	Purchase
FreeEpView	-0.321(0.219)
ReviewVolume	0.166***(0.009)
Price	0.019***(0.001)
Adult	3.120***(0.531)
Complete	-1.031***(0.020)
PublishDate	-0.088***(0.369e-02)
Res_FreeEpViewed	1.961***(0.139)
Observations	147,286

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

For econometric analyses, we adopted multilevel mixed-effect models since the error terms for each comic may be autocorrelated and heteroscedastic (Goes et al., 2010). Since comic sales are measured over time, the error terms for each comic may be autocorrelated and heteroscedastic, thereby violating the OLS assumption. Our model is therefore established at two levels. Level 1 reflects the marginal growth of content sales over time with random coefficients and captures the dynamics that underlie the sales pattern of each comic as the number of free episodes increases over the lifecycle. Level 1 is specified as:

$$\Delta Sales_{jt} = \pi_{0j} + \pi_{1j} ContentAge_{jt} + \pi_{2j} ContentAge_{jt}^2 + \pi_{3j} Adult_j + \pi_{4j} Price_j + \pi_{5j} Recommend_{jt} + \pi_{6j} SNS\_Recommend_{jt} + \pi_{7j} Seasonality_j + \varepsilon_{jt}, \text{ where } \varepsilon_{jt} \sim N(0, \sigma_\varepsilon^2) \quad (6)$$

where $ContentAge$ is the number of weeks elapsed since a given comic was released. We also incorporated content characteristics in our model, such as whether a comic belonged to an adult category, the number of recommendations given to a comic, the number of recommendations given to a comic on SNS, the sales price, and the month of content publication to capture seasonality. This model allowed us to capture unobserved content-specific characteristics because it enabled the estimation of population means and random coefficient residuals. The dependent variable corresponds to the marginal sales growth of each comic j, representing the difference in revenue generated by each episode of comic j at week t and week $(t-1)$. Our analytical model reveals that at the early stages after the initial release of a web comic series, the pay-only scheme may outperform WFF pricing but sales will increase under the

WFF scheme as time passes, whereas sales under the pay-only scheme will remain consistent. As with population means and residuals, random coefficients may depend on the pricing scheme. Level 2 therefore depicts differences in the random coefficients of Level 1. These differences stem from the various pricing schemes applied to comics. Level 2 relates random coefficients to pricing schemes as follows:

$$\begin{cases} \pi_{0j} = \mu_{00} + \mu_{01}WaitforFree_j + \xi_{j0} \\ \pi_{1j} = \mu_{10} + \mu_{11}WaitforFree_j + \xi_{j1} \\ \pi_{2j} = \mu_{20} + \mu_{21}WaitforFree_j + \xi_{j2} \\ \pi_{nj} = \mu_{n0} \end{cases} \quad (7)$$

where, $\begin{pmatrix} \xi_{j0} \\ \xi_{j1} \\ \xi_{j2} \end{pmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{matrix} \sigma_{00}{}^2 & \sigma_{01}{}^2 & \sigma_{02}{}^2 \\ \sigma_{10}{}^2 & \sigma_{11}{}^2 & \sigma_{12}{}^2 \\ \sigma_{20}{}^2 & \sigma_{21}{}^2 & \sigma_{22}{}^2 \end{matrix}\right)$ and

n = 3,4,5,6,7,

where $WaitForFree$ indicates whether a comic is under WFF pricing. We considered only the random effects of the constant, $ContentAge_{jt}$, and $ContentAge_{jt}^2$ because the increase in residual terms expanded the covariance matrix, thereby giving rise to difficulties in estimation (Goes et al., 2010). Substituting Level 2 with Level 1 models, we specify our model as follows:

$$\Delta Sales_{jt} = \mu_{00} + \mu_{01}WaitforFree_j + \mu_{10}ContentAge_{jt} + \mu_{11}WaitforFree_j * ContentAge_{jt} + \mu_{20}ContentAge_{jt}^2 + \mu_{21}WaitforFree_j * ContentAge_{jt}^2 + \mu_{30}Adult_j + \mu_{40}Price_j + \mu_{50}Recommend_{jt} + \mu_{60}SNS_{Recommend\,jt} + \mu_{70}Seasonality_j + \xi_{j0} + \xi_{j1} + \xi_{j2} + \varepsilon_{jt} \quad (8)$$

Our estimation model consists of both random and fixed effects, leaving us with a mixed-effects model. We relied on the maximum likelihood estimation mechanisms to estimate the model parameters (Singer, 1998).

Table 7 presents the estimated results. The estimation results regarding $WaiforFree$ show the relative effects of comics under WFF pricing compared with those under pay-only pricing right after content release (i.e., $ContentAge = 0$). The estimated coefficient is negative (-0.179) and significant at the 0.01 level, suggesting that immediately after release, comics available under WFF pricing generate lower sales than those offered under the pay-only scheme. The estimated coefficient of $ContentAge$, which shows the population mean of π_{1i} for comics under regular pricing (i.e., μ_{10}), reflects the sales patterns that include the number of weeks elapsed since the publication of a given comic. The results indicate that μ_{10} is negative (-0.172) and statistically significant at the 0.01 level, implying that sales from comics sold under pay-only pricing decrease after episodes are released. The population mean of π_{1i} for comics available through WFF pricing is determined using μ_{10} + μ_{11}. The results suggest that μ_{10} + μ_{11} is positive (0.357) and statistically significant at the 0.01 level, indicating that the sales generated from comics under WFF pricing increase with the lifecycles of these products. In sum, at the early stage of the product life cycle, comics under pay-only pricing may yield higher sales than those under WFF pricing, but the latter outperforms the former as time progresses. In addition, the estimated coefficient of μ_{21} is negative (-0.008) and significant at the 0.01 level, pointing to a U-shaped pattern of sales generated from WFF pricing across product lifecycles.

The results in Table 7 show that the demand for comics offered under pay-only pricing exhibits a relatively constant decrease in sales after release, a pattern that is commonly observed in sales of digital content (Ma et al., 2014). The economic value of content products decays immediately after their successful introduction. By contrast, the distribution of comics available through WFF pricing exhibits an inverted U-shaped pattern in which demand increases over a much longer period, thereby sustaining the profits of the seller.

Implications and Conclusion

This study investigates the efficacy of the emerging WFF pricing design in monetizing serialized web comics that are characterized as addictive and habit-forming content products, with attention devoted to three aspects: (1) wait-or-purchase decisions of consumers that enter the market in the presence of free episodes, (2) the performance of the WFF and pay-only options, and (3) the effect of free episodes accumulated over time when deferring the switch from free usage to paid usage. To this end, we extend the habit formation framework (O'Donoghue & Rabin, 1999) to the domain of pricing to unravel how free samples of addictive digital content acquired through waiting and delayed gratification affect dependency behaviors that, in turn, impact the inclination of customers to purchase content and thus the monetization strategies implemented by companies. On the basis of two concepts that are well-established in the behavioral economics literature (i.e., habit formation and present bias), the current research demonstrates that WFF pricing can effectively increase the WTP of low-valuation consumers as habit formation builds up over time with the free consumption of serial content. In the end, this increase converts otherwise non-paying consumers into paying customers because a reinforcement of habit formation, and an increase in present bias motivates consumers to switch from waiting to buying.

Table 7. Estimated Results for Content Sales Pattern		
		Sale
Fixed effects		
WaitForFree	μ_{01}	-0.179*** (0.027)
ContentAge	μ_{10}	-0.172*** (0.041)
WaitForFree * ContentAge	μ_{11}	0.529*** (0.058)
ContentAge_sq	μ_{20}	-0.001(0.002)
WaitForFree * ContentAge_sq	μ_{21}	-0.008*** (0.002)
Adult	μ_{30}	-1.260*** (0.398)
Price	μ_{40}	-0.005*** (0.001)
Recommend	μ_{50}	1.143*** (0.092)
SNS_Recommend	μ_{50}	0.023*** (0.034)
Seasonality (month fixed effect)		YES
Constant	μ_{00}	4.739*** (0.402)
Random effects		
Variance for residuals (within)		1.971*** (0.155)
Variance for ξ_{j0} (across)		1.081*** (0.273)
Variance for ξ_{j1}		0.026*** (0.004)
Variance for ξ_{j2}		0.452*** (0.081)
Observations		2,548
Log-likelihood		-2,580

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

However, the results also indicate that consumers' susceptibility to purchasing varies depending on a number of factors, including the characteristics of consumers, content, and pricing designs; for example, young consumers, who are relatively less resistant to temptation than older consumers, are predisposed to purchase goods rather than wait for them to be converted into free products. The days remaining until free conversion and the content quality also positively affect purchase behaviors.

For comprehensive investigations, we leveraged a combination of analytical derivations and empirical assessments, including structural estimations. The theoretical expansion and the empirical outcomes in this work highlight several important scholarly and practical implications. In terms of research, this study theorizes and empirically validates WFF pricing as a legitimate monetization strategy for real-world business environments. We extend the notion of the perception-perfect strategy by refining the utility function of consumers who wish to purchase highly addictive digital goods and observing their optimal decision-making behaviors on the basis of perception perfectness—an equilibrium strategy concept that has rarely been applied to the exploration of consumers' purchase patterns in online markets. Furthermore, whereas the prior literature on free trials and sampling has focused primarily on how free products diminish quality uncertainties or increase network sizes for the enhancement of advertising revenues, our work concentrates on the extent to which free content and waiting disutility impact habit formation and present bias, which can motivate non-paying consumers to become paying customers.

The findings related to sales variations over time also provide digital content sellers with a variety of insights into consumers' strategic behaviors, as well as their inherent vulnerabilities—information that is crucial for sellers to establish effective strategies for business models, advertising, content versioning, inventory controls, and customer satisfaction. For example, in implementing WFF pricing, managers could identify individual users' preferences for immediate versus delayed gratification and distribute the corresponding utility maximization function. Armed with the knowledge obtained from this identification, managers could develop effective marketing campaigns for individual targeting and recommendations. Content providers could also establish recommendation systems that prominently display hedonic content to impatient users in order to increase cross-selling. Likewise, more attractive promotions should be delivered to patient consumers to convert them into paying customers. The timing of coupon-based targeting is another critical driver of promotional success because consumers differ in terms of patience, time preferences for gratification, and their consumed stock of addictive digital goods.

To further benefit from WWF pricing, managers might consider offering additional incentives and promotions to drive increased conversion into paid options, which would help them extend the period of sales growth under the inverted U-shaped pattern. Currently, most companies impose a fixed price on each episode regardless of its characteristics (i.e., age, popularity), but a flexible and dynamic pricing option may reduce not only physical but also psychological barriers to switching, which would further extend periods of growth under the inverted U-shaped pattern and enhance the efficacy of WFF pricing. However, optimal pricing under the WFF scheme is a complex problem that requires sophisticated analyses and experimentations. Our findings serve as an initial step in the development of more comprehensive and innovative WFF pricing schemes that would ideally benefit both users and sellers of digital content.

Finally, our product-level analysis shows that in addition to driving increased revenue, WFF pricing sustains the popularity of products over longer periods compared to pay-only alternatives. Nevertheless, as the number of free episodes consumed while waiting exceeds a threshold, the probability of conversion decreases. The inverted U-shaped pattern of sales over time provides content vendors that sell addictive entertainment content goods, such as games, comic books, and TV series, with a number of strategic vantage points from which to monetize digital creations. For example, WFF pricing may enable content providers to solve inherent problems with the sales patterns of their products. Most entertainment content products are “trendy” in the sense that they are sold in the early stages of publication, after which revenue generation rapidly decays. Managers can address this problem by applying the WFF scheme more aggressively to products that are “trendy” and short-lived. That is, WFF pricing may help managers extend the lifespan of such content by extending periods of sales growth. Conversely, pay-only pricing may more effectively drive the sales of reliable sellers because their threshold points under the inverted U-shaped curve come at relatively later periods compared with those of their trendy counterparts.

Several limitations in the current study could be addressed in future research. An extension of our analytical modeling could reveal deeper insights into the dynamics of WFF pricing. For example, the underlying concepts of equilibrium could be more dynamically defined in order to illuminate players’ strategic behaviors under WFF pricing. We developed a static game theoretic model for simplicity, but future research could adopt evolutionary game frameworks wherein consumers dynamically change their strategic choices to optimize payoffs. This approach would allow for a more comprehensive reflection of consumers’ strategic behaviors.

In our empirical setting, conversion into free content occurs on a weekly basis across all episodes. To unravel the salient aspects of the mechanism in WFF pricing, researchers should look into the dynamic aspects of delayed consumer gratification by manipulating the number of remaining days until content becomes free. Given that impatience may vary substantially across digital content consumers and content products, variations in the remaining days until conversion may enhance the effectiveness of WFF pricing. Although our analyses controlled for quality variations at the comic level through the use of proxies for content quality (i.e., the number of recommendations on comic titles) and product-specific fixed effects, we disregarded possible quality variations at the episode level. It may be reasonable to assume that a consumer’s level of enjoyment and satisfaction varies across numerous episodes, but full incorporation of such variations would have rendered our analytical model excessively complex and may have introduced inaccuracies in our empirical validations. Additionally, accurate, high-quality data were available only at the comic level and not at the individual episode level, which prevented us from broadening our exploration of variation effects. We accordingly focused on the parsimony of the analytical model and the tighter integration of the analytical and empirical approaches, possibly at the expense of additional insights that could have been obtained from an inquiry into episode-level variations in quality. However, this is a promising avenue for future research. Finally, our study was devoted exclusively to the comics category, which comprises serialized digital content infused with highly hedonic and habit-forming elements. Future research could extend our findings and improve their generalizability by delving into the effectiveness of WFF pricing for various digital content categories.

In conclusion, this study evaluates the effectiveness of the WFF pricing scheme, specifically regarding whether it can change consumer behaviors in relation to their consumption of serialized digital content and how it can catalyze the manner in which such commodities are monetized. The key findings suggest that implementing pricing structures on the basis of consumers’ discount rates and perceived utility functions can serve as effective revenue-earning strategies, at least for serialized digital content with habit-forming and addictive components. The tenets attached to WFF pricing can be applied not only to serialized content but also to various contexts that involve the sale of digital goods. These include introductions to newly released music albums and movie trailers, in-app purchases for game tools, and app version upgrades, for which consumers are often willing to pay for immediate satisfaction rather than wait for free content. As the digital content market is rapidly expanding, identifying monetization strategies that guarantee a stable revenue stream is an important challenge faced by content developers, publishers, and platform owners. Our findings suggest that WFF structures that are grounded in habit formation and present bias can effectively elicit new demand and secure profits from the sale of digital content over longer periods.

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Appendix A

Proofs of Results in "Model" Section

Proof of Proposition 1: By definition of the perception-perfect strategy, a consumer starts purchasing immediately at the entry period t if and only if $U^t(t) \geq U^t(\tau)$ for all $\tau > t$. Note that:

$$U^t(t) = (f_t + 1)v - p + \beta \sum_{\tau=1}^{T-t} \delta^\tau (v - p) \qquad \text{(A1)}$$

$$U^t(t+1) = f_t v - \sigma f_t + \beta[\delta(2v - p) + \sum_{\tau=2}^{T-t} \delta^\tau (v - p)] \qquad \text{(A2)}$$

Where $U^t(t+1)$ is the intertemporal utility of initiating purchase at $t+1$, evaluated at t. The first two terms in equation (A2) are the t-period instantaneous utility from waiting: $u_t(a_t = W; k_t = f_t) = f_t v - \sigma f_t$. Inside the bracket of (A2), the first term is the discounted $(t+1)$-period instantaneous utility: $u_{t+1}(a_{t+1} = B; k_{t+1} = 2 + \gamma f_t) = 2v - p$. Here, the consumer can enjoy two episodes (one for free and one through purchase) because she waited in the previous period. From period $(t+2)$ and beyond, the consumer buys one episode per period, and the instantaneous utility $(v - p)$ is accordingly discounted as in the second term inside the bracket. Solving $U^t(t) \geq U^t(t+1)$ results in $v \geq \frac{p - \sigma f_t}{1 - \beta\delta} \equiv \hat{v}_t(\sigma, \beta, \delta, f_t)$. We can similarly specify:

$$U^t(t+2) = f_t v - \sigma f_t + \beta[\delta(v - \sigma(1 + \gamma f_t)) + \delta^2(2v - p) + \sum_{\tau=3}^{T-t} \delta^\tau (v - p)], \qquad \text{(A3)}$$

and show that $U^t(t+1) \geq U^t(t+2)$ as long as $v \geq \hat{v}_t(\sigma, \beta, \delta, f_t)$, and γ is sufficiently high.[18] Repeated iteration shows that $U^t(t) \geq U^t(\tau)$ for all $\tau > t$ among consumers with valuations higher than $\hat{v}_t(\sigma, \beta, \delta, f_t)$. These consumers accordingly begin to purchase immediately at time t, which proves part (i) of the proposition. On the other hand, consumers with valuations $v < \hat{v}_t(\sigma, \beta, \delta, f_t)$ choose to wait at period t since $U^t(t) < U^t(t+1)$. At period $t+1$, they evaluate their intertemporal utilities again, but this time from the perspective of period $t+1$.

$$U^{t+1}(t+1; a_t = W) = 2v - p + \beta \left[\sum_{\tau=1}^{T-(t+1)} \delta^\tau (v - p)\right] \qquad \text{(A4)}$$

$$U^{t+1}(t+2; a_t = W) = v - \sigma(1 + \gamma f_t) + \beta \left[\delta(2v - p) + \sum_{\tau=2}^{T-(t+1)} \delta^\tau (v - p)\right] \qquad \text{(A5)}$$

Applying an analogical process, $U^{t+1}(t+1; a_t = W) \geq U^{t+1}(t+2; a_t = W)$ leads to $v \geq \frac{p - \sigma(1 + f_t\gamma)}{1 - \beta\delta} \equiv \hat{v}_{t+1}(\sigma, \beta, \delta, \gamma, f_t)$, and these consumers with $\hat{v}_{t+1}(\sigma, \beta, \delta, \gamma, f_t) \leq v < \hat{v}_t(\sigma, \beta, \delta, f_t)$ will switch from wait to buy at period $t+1$. Repeated iteration yields subsequent thresholds, $\hat{v}_{t+m}(\sigma, \beta, \delta, \gamma, f_t) \equiv \frac{p - \sigma(\sum_{\tau=0}^{m-1} \gamma^\tau + f_t \gamma^m)}{1 - \beta\delta}$, for each $(t+m)$th period. This concludes the proof of part (ii) of the proposition. Q.E.D.

Proof of Corollary 1: (i) According to Proposition 1(i), a consumer who realizes a value $v \geq \hat{v}_t(\sigma, \beta, \delta, f_t)$ initiates purchase immediately upon entry. Note that, given $\hat{v}_t(\sigma, \beta, \delta, f_t) \equiv \frac{p - \sigma f_t}{1 - \beta\delta}$, $\frac{\partial \hat{v}_t}{\partial \sigma} \leq 0, \frac{\partial \hat{v}_t}{\partial f_t} \leq 0$ *and* $\frac{\partial \hat{v}_t}{\partial \beta} \geq 0$. Therefore, $\hat{v}_t(\sigma, \beta, \delta, f_t)$ increases in β and decreases in σ and f_t, which implies that the probability a consumer makes a purchase upon entry decreases in β while increases in σ and f_t for any plausible cumulative distribution function for *v*.

(ii) According to Proposition 1(ii), those consumers who have been waiting and consuming free episodes until $(t+m-1)$th period have valuations $v < \hat{v}_{t+m-1}(\sigma, \beta, \delta, \gamma, f_t)$. Out of these consumers, those with valuations $\hat{v}_{t+m}(\sigma, \beta, \delta, \gamma, f_t) \leq v < \hat{v}_{t+m-1}(\sigma, \beta, \delta, \gamma, f_t)]$ will switch to buying at $(t+m)$ and the remaining consumers with $v < \hat{v}_{t+m}(\sigma, \beta, \delta, \gamma, f_t)$ will continue to wait. Therefore, the probability that a consumer switches to buy at $(t+m)$ decreases in $\hat{v}_{t+m}(\sigma, \beta, \delta, \gamma, f_t) \equiv \frac{p - \sigma(\sum_{\tau=0}^{m-1} \gamma^\tau + f_t \gamma^m)}{1 - \beta\delta}$. Since $\frac{\partial \hat{v}_{t+m}}{\partial \sigma} \leq 0, \frac{\partial \hat{v}_{t+m}}{\partial f_t} \leq 0, \frac{\partial \hat{v}_{t+m}}{\partial \gamma} \leq 0, \frac{\partial \hat{v}_{t+m}}{\partial m} \leq 0$ and $\frac{\partial \hat{v}_{t+m}}{\partial \beta} \geq 0$, the probability of switching increases in σ, f_t, γ, m and decreases in β. Q.E.D.

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[18] $\frac{\tau-2}{\tau-1} \leq \gamma \leq 1$ at τ, to be exact. We focused on parameter ranges with high γ (i.e., habit formation does not decay at an excessively fast rate) because we were interested in how the addictive nature of web cartoons influences consumer behavior.

Proof of Proposition 2: Using the same definition of perception-perfect strategy, let $U^t(\tau)$ be the intertemporal utility of a consumer who initiates purchase at some period $\tau \geq t$, evaluated at t. Then, we can specify intertemporal utilities under the pay-only scheme as:

$$U^t(t) = \bar{f}v + t(v-p) + \beta \sum_{\tau=1}^{T-t} \delta^\tau (v-p) \qquad \text{(A6)}$$

$$U^t(t+1) = \bar{f}v - \sigma\bar{f} + \beta[\delta(t+1)(v-p) + \sum_{\tau=2}^{T-t} \delta^\tau (v-p)] \qquad \text{(A7)}$$

We can see that $U^t(t) \geq U^t(t+1)$ whenever $v \geq p - \frac{\sigma\bar{f}}{(1-\beta\delta)t} \equiv \hat{v}^P(\delta,\beta,\sigma,t,\bar{f})$. Thus, consumers who realize high enough valuations of $v \geq \hat{v}^P(\delta,\beta,\sigma,t,\bar{f})$ will initiate purchase upon entry.[19] This concludes part (i) of the proof.

For those consumers with low valuations of $v < \hat{v}^P(\delta,\beta,\sigma,t,\bar{f})$, they will end up never making a purchase (i.e., $a_\tau^{P*} = N$ for $\forall\ t \leq \tau \leq T$). Consider a consumer who enters at time t and does not make a purchase ($a_t^P = N$). Suppose this consumer makes another buy or not buy decision at $t+1$. The consumer compares the following intertemporal utilities:

$$U^{t+1}(t+1; a_t = N) = \bar{f}v + (t+1)(v-p) + \beta \sum_{\tau=1}^{T-(t+1)} \delta^\tau (v-p) \qquad \text{(A8)}$$

$$U^{t+1}(t+2; a_t = N) = \bar{f}v - \sigma\bar{f} + \beta\left[\delta(t+2)(v-p) + \sum_{\tau=2}^{T-(t+1)} \delta^\tau (v-p)\right] \qquad \text{(A9)}$$

The consumer will initiate purchase at $t+1$ if $U^{t+1}(t+1; a_t = N) > U^{t+1}(t+2; a_t = N)$, which leads to valuations $v \geq p - \frac{\sigma\bar{f}}{(1-\beta\delta)(t+1)} > \hat{v}^P(\delta,\beta,\sigma,t,\bar{f})$. Therefore, a consumer with valuations of $v < \hat{v}^P(\delta,\beta,\sigma,t,\bar{f})$ will not switch to purchase at any future date. This concludes part (ii) of the proposition. Q.E.D.

Proof of Corollary 2: From Proposition 2, $\hat{v}_t^P(\sigma,\beta,\delta,\bar{f}) \equiv p - \frac{\sigma\bar{f}}{(1-\beta\delta)t}$ and $\frac{\partial \hat{v}_t^P}{\partial t} \geq 0$. That is, $\hat{v}_t^P(\sigma,\beta,\delta,\bar{f})$ increases in t. On the other hand, from Proposition 1 and Corollary 1, $\hat{v}_t(\sigma,\beta,\delta,f_t) \equiv \frac{p-\sigma f_t}{1-\beta\delta}$ and $\frac{\partial \hat{v}_t}{\partial t} = \frac{\partial \hat{v}_t}{\partial f_t} \cdot \frac{\partial f_t}{\partial t_t} \leq 0$ since $\frac{\partial \hat{v}_t}{\partial f_t} \leq 0$ from Corollary 1 and $\frac{\partial f_t}{\partial t} \geq 0$ by the structure of WFF scheme. Therefore, $\hat{v}_t(\sigma,\beta,\delta,f_t)$ decreases in t. Let $\hat{t} \in [0,T]$ be the value that induces $\hat{v}_{\hat{t}}^P(\sigma,\beta,\delta,\bar{f}) = \hat{v}_{\hat{t}}(\sigma,\beta,\delta,f_t)$, where such value exists since $\hat{v}_t^P$ monotonically increases while $\hat{v}_t$ monotonically decreases in t. Then, since $\frac{\partial \hat{v}_t^P}{\partial t} \geq 0$ and $\frac{\partial \hat{v}_t}{\partial f_t} \leq 0$, $\hat{v}^P(\delta,\beta,\sigma,t,\bar{f}) < \hat{v}(\delta,\beta,\sigma)$ for $\forall t < \hat{t}$, while $\hat{v}^P(\delta,\beta,\sigma,t,\bar{f}) \geq \hat{v}(\delta,\beta,\sigma)$ for $\forall t \geq \hat{t}$. Q.E.D.

[19] One can easily confirm that $U^t(t+1) > U^t(t+2)$ whenever $v \geq \hat{v}^P(\delta,\beta,\sigma,t,\bar{f})$ and γ is sufficiently high, as in the same manner provided in the proof of Proposition 1. A recursive application is also analogous.

Appendix B

Instrumental Variable (IV)

There is the possibility that $InitialFree_{ij}$ (f_{ij}) is endogenous due to the omitted variables that are jointly correlated with the decision of consumers to purchase. An omitted variable can be, for instance, a consumer's interest in a specific comic. For example, individuals who are more intrigued by a certain comic may consume more free episodes. This unobservable factor may be positively correlated with both the number of free episodes consumed by each customer and a consumer's purchase decision. Thus, the naive estimation may inflate the true impact of the number of consumed free episodes on the decision to buy comics. We put forward consumer i's historical consumption of free episodes ($HistFreeConsump$) as an IV to alleviate potential endogeneity issues. $HistFreeConsump$ is the ratio of the number of free episodes previously consumed by each consumer to the number of available free episodes prior to the decision to take advantage of free episodes of web comic j. The intuition behind the use of this IV is that the extent of past consumption of free episodes is likely correlated with the subsequent or present consumption of free episodes but uncorrelated with unobservables that determine a consumer's decision to buy current comic j. For example, consumers' past free consumption is likely correlated with the current consumption of available free episodes, but uncorrelated with unobservable factors which may determine their purchase decision of payable episodes in current comic j. A similar method of identifying IVs was used by Forman et al. (2008), who selected an instrument for endogenous variables with lagged values. The correlations of $HistFreeConsump$ with $InitialFree_{ij}$ (f_{ij}) is 0.88. We also conducted weak instruments tests (Stock & Yogo, 2005) using the F-statistics from the first-stage equation. The obtained F-statistics is significantly higher than the suggested rule of thumb for weak instruments (i.e., a value of 10), implying that the proposed IV is valid.

Appendix C

Computing the Number of Thresholds $PayEp$ in the WFF Pricing Market

While one giveaway episode results in an up to 13% increase in the odds that a consumer will purchase the next paid episode, the number of paid episodes offered through WFF is significantly lower than those offered through regular pay-only pricing. Thus, we compute the threshold number of paid episodes that publishers can take in an advantageous position in WFF markets. The revenue generated by regular pay-only pricing can be computed as:

$$0.240\ \ PayEp_{Regular} *\ NumBuyers_{Regular}=, \qquad \text{(C1)}$$

where 0.240 represents the average price (in USD) of each episode. Similarly, the revenue generated by WFF pricing can be computed as:

$$0.240\ \ PayEp_{WFF} *\ NumBuyers_{WFF} \qquad \text{(C2)}$$

In order for WFF pricing to generate higher revenue than a regular pay-only pricing scheme:

$$0.240 * PayEp_{Regular} *\ NumBuyers_{Regular} \leq 0.240\ \ PayEp_{WFF} *\ NumBuyers_{WFF} \qquad \text{(C3)}$$

Since one free episode can yield an up to 13% increase in the odds of purchasing the next paid episode in WFF pricing, we can rewrite Equation C3 as follows:

$$0.240 * PayEp_{Regular} *\ NumBuyers$$

$$\leq 0.240 *\ PayEp_{WFF} * [NumBuyers * (1 + 0.13 * InitialFree)] \qquad \text{(C4)}$$

At week *t*, the number of episodes in regular pay-only pricing would equal $free\ sample +\ PayEp_{Regular}$, whereas it is $free\ sample\ +\ InitialFree\ +\ PayEp_{WFF}$ in the WFF pricing scheme. Assuming that Comic A, which is offered through regular pay-only pricing, and Comic B, which is available through WFF pricing are released in the same week and the number of free samples is equal, the total number of episodes in both comics would be the same, resulting in$free\ sample + PayEp_{Regular} = free\ sample\ +\ InitialFree\ +\ PayEp_{WFF}$. This would yield, $PayEp_{Regular}\ =\ InitialFree\ +\ PayEp_{WFF}$, which results in 7.692 $\leq PayEp_{WFF}$. $NumBuyers$ represents the number of consumers who purchase episodes, and $PayEp_{Regular}$ and $PayEp_{WFF}$ denote the number of paid episodes available through pay-only and WFF pricing schemes, respectively. Thus, publishers are in an advantageous position in WFF markets when the number of episodes available for purchase ($PayEp$) exceeds a certain threshold (e.g., eight).

Appendix D

Survival Analysis

A core assumption of the Cox hazard model is that the effects of covariates X on the hazard ratio remain constant over survival time. To test the independence of X from survival time, we conducted a Schoenfeld residual test (Grambsch & Therneau, 1994), which suggests that $AccumulateFree$, $AccumulateFree^2$, and $FreeEpConsume$ violate the core assumption (Table D1). We therefore looked at time-varying effects (TVE) in relation to the covariates by employing the extended Cox hazard model to enhance the accuracy of our model specification (Scherer et al., 2015). Details of the Schoenfeld residual tests are available upon request.

Table D1. Testing Time-Independence of X in PH Assumption

Variables	Rho	χ^2	Test
AccumulateFree	0.245	132.491	Sig
AccumulateFree_sq	-0.327	158.016	Sig
InitialFree	-0.171	46.107	Sig
DayRemain	0.019	0.491	Insig
PayEp	-0.040	2.448	Insig
Recommend	-0.045	2.320	Insig
SNS_Recommend	0.044	2.312	Insig
Adult	-0.014	0.428	Insig
Price	0.009	0.101	Insig
Age	0.002	0.001	Insig
Gender	0.037	1.853	Insig

Appendix E

Matching Mechanisms (WFF vs. Pay-Only Schemes)

To resolve confounding issue that may stem from differences between comics under WFF and pay-only pricing, we conducted coarsened exact matching (CEM), through which inherent differences between two product categories were minimized. The matching results and the corresponding robustness check (i.e., PSM) are presented here (Tables E1 and E2).

Table E1. Results of CEM

	Mean		*t*-stat
	WFF	Regular	
Discount	0.253	0.255	0.188
FixedPrice	0.459	0.455	1.190
PublishDate	20323.55	20321.26	1.501
PublishWeek	1.059	1.068	0.841
Adult	0.219	0.217	1.301
Recommend	33.094	34.817	0.441
SNS_Recommend	4.505	5.013	1.703
Author_Exp	2.782	3.045	1.052
Genre	0.362	0.310	0.711

Table E2. Summary of Descriptive Statistics of Matching Variable (PSM)

	Mean		*t*-stat
	WFF	Regular	
Discount	0.202	0.204	0.871
FixedPrice	0.488	0.501	1.639
PublishDate	20311.18	20317.77	0.962
PublishWeek	1.196	1.120	1.113
Adult	0.394	0.371	1.010
Recommend	34.734	33.121	0.900
SNS_Recommend	3.663	3.734	0.914
Author_Exp	2.931	3.077	0.880
Genre	0.300	0.308	0.693