Theory Appendix

In this appendix, we provide a stylized model based on our empirical setting to analyze the effect of competition on author behavior. The general idea is that in a market with imperfect competition, a producer enjoys rent whose size increases in its market share. The entry of new products erodes the marginal return to creative activities, thereby discouraging the producer’s incentive to engage in creative activities. On the other hand, the entry of products incentivizes the producer to protect its market share or steal other producers’ market shares. This business-stealing effect (and the pressure of protecting businesses from being stolen) inspires creative effort. Such a trade-off between market erosion (or rent dissipation) and business stealing (or escaping competition) is central in the study of how competition affects innovation (e.g., Aghion et al. 2005; Vives 2008) and how competition disciplines managerial slack (e.g., Schmidt 1997; Raith 2003). We model this mechanism in the current empirical setting to investigate how it affects authors’ routine efforts for quantity expansion and creative efforts for novelty improvement under a given contractual relationship.

1 Model Setup

In the online novel-writing market, after a chapter is written, the marginal cost of serving an additional reader is zero. Hence, a book earns rent whose size depends on its readership. In the product space, a book can be characterized by its match with readers’ taste and its quality. In a market of this kind, typically a producer can use three strategies to compete: (1) pricing, (2) market positioning, and (3) changing product attributes. In the current setting, the price mechanism is muted because the platform sets the same unit price of all books to readers. Moreover, we study contracted books whose market positions (category) are set as part of the contractual agreement. Therefore, we focus on the third strategy.

As described in Section 2.2, an author can change the attributes of an ongoing book project in two ways. First, an author can exert routine effort to increase the length of chapters and frequency of updates. This quantity-expansion strategy caters to readers’ preferences for faster consumption. Second, an author can exert creative effort to improve novelty of a book. Just as in any creative production, there is uncertainty regarding whether such creative effort leads to greater novelty.

With the above empirical background, consider $N$ authors with equal ability in the market. Each author independently produces one and only one book project, whose market position is fixed. The unit price of all books is normalized to 1, and thus the demand (readership) of a book is also its revenue. Author $i$ aims to maximize her profit by exerting routine effort $l_i$ to produce
quantity and creative effort $e_i$ to stochastically improve novelty. To save on notation, $t_i$ will also indicate the length of writing, and $e_i$ also indicate the probability of a successful improvement of novelty. The platform can take action $p_i$ to promote book $i$.

Based on their contractual status, there are three types of books in the market: revenue-sharing books, fixed-price books, and books without contracts. Under the revenue-sharing contract, an author splits the revenue equally with the platform. Under the fixed-price contract, an author receives a fixed price per unit of the quantity she produces. Since we empirically do not analyze the books without contracts, we regard them as the numeraire and do not explicitly model them. To facilitate the analysis, we make the following assumptions.

**Assumption 1** The total market demand (overall reader time) is fixed and normalized to one.

**Assumption 2** The demand for a book increases in its own length and novelty, and decreases in its competitor length and novelty because of the business-stealing effect. The market share an author can steal from another book through increasing its book length or novelty is a decreasing exponential function of the number of books in the market, $N$.

**Assumption 3** The costs of exerting routine effort and creative effort are separable.

**Assumption 4** A book’s demand increases in the platform’s promotion it receives. The platform’s marginal cost of promoting a book decreases in $N$.

Assumption 1 fits the empirical observation that the traffic (measured by daily user volume) on the platform changed little after competition intensified. Our empirical setting thus allows us to isolate the pure competition effect from the market size effect.

Assumption 2 assumes a reduced-form competitive relationship between books. A book with more desirable attributes (faster updates and novelty) steals demand (readership) from competitors. The size of this business-stealing effect from each competitor decreases in the total number of books in the market because as $N$ increases, each book has a smaller market share to steal from. We use an exponential function for analytical simplicity.

Assumption 3 is a technical assumption that separates the decision on routine effort from the decision on creative effort. It can be relaxed easily.

Assumption 4 helps simplify the platform promotion strategy. The platform uses promotion to help a book enlarge its demand at the cost of reducing promotion resources for other books (particularly non-contracted books). The assumption that the marginal cost of promotion decreases in $N$ is to capture the platform’s main purpose of promoting non-contracted books, which is to encourage the participation of new authors (recall Section 2.2). When the number of new books increases, this need to encourage participation decreases.

With these four assumptions, we construct a simple model that captures the main features of the empirical setting to illustrate the key mechanisms and deliver testable results. We discuss how
relaxing each of these assumptions would change the results in Discussion section. We start with books under the revenue-sharing contract, which account for the dominant share of all contracted books.

1.1 Revenue-sharing Contracts

Under a revenue-sharing contract (indicated with superscript \( S \)), author \( i \) and the platform receive the following payoffs, \( \pi^S_i \) and \( \Pi^S_i \), respectively, from book \( i \).

\[
\pi^S_i = \frac{1}{2} \left[ \frac{1}{N} + \beta N^{-\sigma} \sum_{j \neq i} (l_i - l_j) + \gamma N^{-\sigma} \sum_{j \neq i} (I_i(e_i) - I_j(e_j)) + \alpha(p_i) \right] - c(l_i) - c(e_i), \quad (1)
\]

\[
\Pi^S_i = \frac{1}{2} \left[ \frac{1}{N} + \beta N^{-\sigma} \sum_{j \neq i} (l_i - l_j) + \gamma N^{-\sigma} \sum_{j \neq i} (I_i(e_i) - I_j(e_j)) + \alpha(p_i) \right] - g(p_i, N). \quad (2)
\]

Equation (1) describes author \( i \)'s payoffs. The fraction \( \frac{1}{2} \) comes from her equal share of the total revenue. In the bracket, \( \frac{1}{N} \) represents the market demand for book \( i \) absent any additional forces because of Assumption 1 and the assumption that all books are equally good \( \text{ex ante} \). The term \( \beta N^{-\sigma} \sum_{j \neq i} (l_i - l_j) \) reflects Assumption 2. When facing chapters of books \( i \) and \( j \), a reader spends more time on the lengthier one, which in turn reduces the time spent on the other book. The coefficient \( \beta N^{-\sigma} \) captures the business stealing effect from each rival book if its author increases one unit of routine effort to produce one more unit of quantity. \( \sum_{j \neq i} (l_i - l_j) \) captures the number of available books an author can steal market shares from or lose its market share to. \( \beta > 0 \) measures readers’ sensitivity to the quantity difference between books; \( \sigma > 0 \) captures how easily the entry of new books erodes the market share of the existing books. When \( \sigma \) is larger, it is easier for new books to erode the demand for the existing books. Similarly, the term \( \gamma N^{-\sigma} \sum_{j \neq i} (I_i(e_i) - I_j(e_j)) \) captures the effect of novelty competition on gaining readership. Here, \( \gamma > 0 \) measures readers’ sensitivity to novelty, and \( I_i \) is an indicator function that equals 1 if novelty is improved and 0 otherwise. After exerting effort \( e_i \), author \( i \) can improve the novelty of her writing with probability \( e_i \). Thus, \( I_i(e_i) - I_j(e_j) = e_i(1 - e_j) - (1 - e_i)e_j \). The term \( \alpha(p_i) \), with \( \alpha'(p_i) > 0 \), captures book \( i \)'s additional readership caused by platform promotion.

The last two terms are the cost functions for routine effort and creative effort. By Assumption 3, they are separable. We further assume \( c'(l_i) > 0, c''(l_i) > 0, c'(e_i) > 0, \) and \( c''(e_i) > 0 \) to ensure the existence of interior solutions.

Equation (2) describes the platform’s payoffs. The benefit part is the same as the one for author \( i \) because they equally split the revenue. The only new term is \( g(p_i, N) \), which is the cost of promoting book \( i \) in terms of the reduction of other books’ promotion resources. We assume that \( \frac{\partial g}{\partial p_i} \geq 0 \) to ensure the existence of solutions. By Assumption 4, \( \frac{\partial g^2}{\partial p_i \partial N} < 0 \).
1.2 Fixed-Price Contracts

We now turn to the books under the fixed-price contract. The payoffs to an author under this contract and the platform, indicated with a superscript $F$, are described below, respectively:

$$\pi_i^F = \theta l_i - c(l_i) - c(e_i),$$

$$\Pi_i^F = \frac{1}{N} + \beta N^{-\sigma} \sum_{j \neq i} (l_i - l_j) + \gamma N^{-\sigma} \sum_{j \neq i} (I_i(e_i) - I_j(e_j)) + \alpha(p_i) - \theta l_i - g(p, N).$$

The author’s payoff is simpler in this case because she is paid by the word at a predetermined price $\theta$ for a unit output. The platform claims the entire residual net of the pay to the author. The promotion cost function is the same as the one under the revenue-sharing contracts.

2 Equilibrium Analysis

Under the given contractual formats, authors simultaneously and independently choose their optimal levels of routine and creative efforts to maximize their objective functions specified above. The platform chooses the optimal level of promotion for each book at the same time. The market clears when the supply equals the demand.\(^1\) Below we add superscripts $\{S, F\}$ to indicate equilibrium outcomes for the decision variables under the two contractual types.

2.1 Solutions

For revenue-sharing books, under the regularity conditions to ensure interior solutions, the optimal responses are determined by the following first order conditions:

$$\frac{\beta}{2} N^{-\sigma} (N - 1) = c'(l_i^S),$$

$$\frac{\gamma}{2} N^{-\sigma} (N - 1) = c'(e_i^S),$$

$$\frac{1}{2} \alpha'(p_i^S) = \frac{\partial g(p_i^S, N)}{\partial p_i^S}.$$

The left-hand side of equation (5) is the marginal benefit of increasing routine effort: a book steals $\frac{\beta}{2} N^{-\sigma}$ from each of the $N - 1$ competitors. The right-hand side is the marginal cost of exerting routine effort. Similarly, when an author exerts one more unit of creative cost to improve quality, her book will steal $\frac{\gamma}{2} N^{-\sigma}$ from each of the $N - 1$ competitors.

The solutions to the optimization problems under the fixed-price contract are straightforward. Since the payoff of an author under fixed-price is independent of market performance, she has no

\(^1\)With the demand being fixed by Assumption 1, clearing the market requires that the increased consumption of the contracted books should be offset by the decreased consumption of the non-contracted books. This is feasible given that empirically the non-contracted books are four times as many as the contracted books.
incentive to exert any amount of creative effort: \( c_i^F = 0 \). Under the regularity conditions that we have imposed on the functional forms to ensure interior solutions, the optimal levels of routine effort and platform promotion are determined by the following first order conditions:

\[
\theta = c'(l_i^F),
\]

\[
\alpha'(p_i^F) = \frac{\partial g(p_i^F, N)}{\partial p_i^F}.
\]

Note that although a revenue-sharing author will always exert more creative effort than a fixed-price author, this is not necessarily true for routine effort. If the price paid to a fixed-price author is large enough, she may exert more routine effort (write a lengthier book) than a revenue-sharing book.

From equations (7) and (9), the platform equalizes the net marginal benefit of promoting either type of contracted books and will allocate more promotion resources to fixed-price books, of which the platform claims the entirety, instead of half, of the residual.

2.2 Comparative Static Analysis

We now consider how an author and the platform respond to an increase in \( N \). For revenue-sharing books, differentiating the first order conditions (equations (5), (6) and (7)) with respect to \( N \), we obtain the following equations.

\[
\frac{dl_i^S}{dN} = \frac{\beta}{2} N^{-\sigma} (1 - \frac{\sigma}{N}) \frac{1}{c''(l_i^S)},
\]

\[
\frac{de_i^S}{dN} = \frac{\gamma}{2} N^{-\sigma} (1 - \frac{\sigma}{N}) \frac{1}{c''(e_i^S)},
\]

\[
\frac{dp_i^S}{dN} = \frac{\partial^2 g(p_i^S, N)}{\partial p_i^S \partial N} \cdot \frac{1}{2\alpha''(p_i^S)} - \frac{\partial^2 g(p_i^S, N)}{\partial p_i^2}.
\]

By the convexity assumption of the cost functions, \( c''(l_i^S) > 0 \) and \( c''(e_i^S) > 0 \). Hence, the signs of \( \frac{dl_i^S}{dN} \) and \( \frac{de_i^S}{dN} \) both depend on the sign of \( 1 - \frac{\sigma}{N} \). The intuition is that the entry of new books (an increase in \( N \)) erodes the market share of book \( i \), which decreases the business that an existing book can steal from another book. However, exerting more effort now allows author \( i \) to steal businesses from more books. The term \( 1 - \frac{\sigma}{N} \) reflects the trade-off between market erosion and business stealing. The overall effect is ambiguous, depending crucially on the magnitude of \( \sigma \).

Consider a special case where \( \sigma = 1 \). In this case, when a new book enters the market, it equally share the market demand with the existing books, and the market-erosion effect is thus proportional to \( \frac{1}{N} \). Then, the business-stealing effect dominates, leading to an unambiguous result: \( \frac{dl_i^S}{dN} > 0 \) and \( \frac{de_i^S}{dN} > 0 \). This result also holds for \( \sigma < 1 \). However, when \( \sigma > 1 \), the elasticity of
market erosion with respect to $N$ is sufficiently large, it is possible that $\frac{dp^S_i}{dN} < 0$ and $\frac{de^S_i}{dN} < 0$. In our empirical setting, the new books on average are unlikely to be more attractive to readers than the existing books. Hence, we will focus on the case where $\sigma \leq 1$.

Consider (7), the second order condition that ensures the existence of interior solutions requires the denominator to be negative (i.e., $\frac{1}{2}\alpha''(p^S_i) - \frac{\partial^2 g(p^S_i, N)}{\partial p^2_i}$). By Assumption 4, $\frac{\partial^2 g(p^S_i, N)}{\partial p_i \partial N}$. Hence, $\frac{dp^S_i}{dN} > 0$.

For fixed-price books, neither the author’s routine effort nor her creative effort depends on $N$. The only response comes from the platform. Differentiating equation (9) with respect to $N$, we obtain:

$$\frac{dp^F_i}{dN} = \frac{\alpha''(p^F_i)}{\frac{\partial^2 g(p^F_i, N)}{\partial p^2_i}}.$$

Again, by the second order condition ($\frac{1}{2}\alpha''(p^F_i) - \frac{\partial^2 g(p^F_i, N)}{\partial p^2_i} < 0$) and by Assumption 4, we have $\frac{dp^F_i}{dN} > 0$.

Compare equations (12) and (13). Under the regularity conditions on the functional form, $|\frac{1}{2}\alpha''(p^S_i) - \frac{\partial^2 g(p^S_i, N)}{\partial p^2_i}| > |\alpha''(p^F_i) - \frac{\partial^2 g(p^F_i, N)}{\partial p^2_i}|$ and $\frac{\partial^2 g(p^S_i, N)}{\partial p_i \partial N} < \frac{\partial^2 g(p^F_i, N)}{\partial p_i \partial N}$. Thus, $\frac{dp^S_i}{dN} < \frac{dp^F_i}{dN}$, implying that entry of new books increases the platform’s promotion of fixed-price books more than that of revenue-sharing books.

We summarize the above analysis in the following two propositions.

**Proposition 1 (Average Effect of Competition)** The entry of new books leads to the following results: (1a) existing authors will increase routine effort to produce more content and update more frequently, (1b) existing authors will increase creative effort to improve the novelty of their works, and (1c) the platform will promote contracted books more intensively.

**Proposition 2 (Effects of Competition under Different Contracts)** The entry of new books leads to the following results: 2a) authors under the fixed-price contract increase neither routine nor creative effort; 2b) authors under the revenue-sharing contract increase both routine and creative efforts; 2c) the increase of the platform’s promotion of contracted books disproportionately favors fixed-price books over revenue-sharing books.

It should be noted that even if the sign of the effect of competition on author effort is certain, the magnitude of this effect depends importantly on readers’ sensitivity to the quantity difference between books $\beta$, and readers’ sensitivity to novelty $\gamma$. In the empirical setting, an author’s improvement of book novelty does not necessarily trigger a uniform response from readers because not all readers may appreciate the same type of novelty. In this case, the effect of competition may appear only modest. The effect of competition also depends on the convexity of the cost functions $c(l^S_i)$ and $c(e^S_i)$. For instance, if the cost goes up very fast when an author tries to improve book novelty, the effect of competition on her creative effort may not be significant.
3 Discussion

Our empirical analysis focuses on Propositions 1 and 2, which are derived under Assumptions 1-4. We now discuss how the results change if we relax these assumptions.

Assumption 1 fixes the market size. We adopt this assumption because empirically we observe stable market demand and we also control for monthly clicks by book category in regressions. Suppose that the market demand also expands because as a result of authors’ increased efforts, the attributes of books become more attractive. Then, the strategy of quantity expansion or novelty improvement will allow a book to steal more business from competitors. Thus, the incentives of revenue-sharing authors to exert routine and creative effort will increase. The results in Propositions (1a), (1b), and (2b) will become stronger and the others will be unchanged.

Assumption 2 imposes a simple functional form for the business stealing effect for analytically tractability. More generally, we can assume $\beta(N)$ and $\gamma(N)$ to be more flexible functions of $N$. For example, one could allow for a nested demand structure. In this situation, the business-stealing effect will be stronger for closer substitutes and weaker for remote substitutes. The basic insights from the model will continue to hold.

Assumption 3 assumes independence between the exertion of routine effort and that of creative effort. Suppose that it does not hold: routine effort and creative effort are inter-dependent. If they are complements, the results remain unchanged. However, if they are substitutes in the sense that they both occupy the author’s time, then the result that both routine effort and creative effort increase with $N$ may not hold. Presumably, it is more costly to adjust creative effort than to increase routine effort, at least for books that have existed in the market for a while. In this case, after competition intensifies, an author will increase routine effort, which may lead to negative correlation between competition and her creative effort. Our empirical evidence does not support that the two types of efforts are not substitutes on average.

Assumption 4 helps simplify the function of platform promotion substantially. In practice, platform promotion can complement an author’s effort. For instance, it is easier to have an effect on readers when the platform promotes books that are updated faster and have a higher level of novelty. In this case, the results in Propositions 1 and 2 will be strengthened. It is also possible that platform promotion alleviates the pressure of increased competition, resulting in a lack of author response to competition. To separate the promotion effect and the competition effect, in the empirical analysis, we show that authors whose books do not receive platform promotion still respond to competition as hypothesized in Propositions 1 and 2.

References

