OPTIMIZING PRICING STRATEGY WITH ROYALTY CONSTRAINTS

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Abstract. In this paper, we present a pricing optimization framework for determining minimum set prices across multiple publication formats under royalty and affordability constraints. Motivated by the not-for-profit mission of the MoKa Reads Collective—“spend the least to support the most”—our goal is to align publication pricing with fair compensation for the author to support themselves while maintaining accessibility for readers. We begin by analyzing price and page count data for programming books using the Google Books API and establish price boundaries for different formats. We then formulate a nonlinear optimization problem where the objective is to maximize expected royalties while penalizing excessive pricing. Constraints enforce pricing monotonicity and reward platforms with higher royalty rates. Using methods such as Sequential Least Squares Programming (SLSQP) and Trust-Region Constrained optimization, we demonstrate how our model provides a rational and principled method for price-setting across digital and print platforms. Our results show consistency between solvers and allow transparent, data-driven pricing decision for our publications.

In this paper we will be exploring a nonlinear optimization problem to determine the best prices for a publication given various distribution formats and producers. The method we use to determine the best price is by using a royalty constraint with the main premise being able to “spend the least to support the most”, this slogan is directly tied to the collective’s interest as a not-for-profit organization to sell publications not for pure profit, but in a affordable, accessible way that enables readers and our interest to being able to support ourselves aligned.

We will firstly discuss about the market, having a look at different books, their prices, page counts and trying to build a relationship with it, thereafter, we can start looking at our problem formulation, ways to approach it, and lastly we will look at results for determining the optimal prices for publications in the MoKa Reads Collective or a minimum set price.

1. Market Analysis and Price-per-Page Relationship

To begin, we analyze the current programming book market to explore the relationship between book price and page count. Although pricing can be influenced by factors such as author contracts, content demand, and publisher margin strategies, we restrict our focus to two primary variables: price and page count.

In this paper, all prices are assumed to be under the Canadian Dollar (CAD) unless explicitly stated not to be. Data was collected using the Google Books API, which provides convenient access to structured information such as book price and page count. This approach eliminates the need for web scraping and allows for efficient data retrieval under usage rate limits.

Given that the majority of our publications will be released in digital format, our pricing analysis focuses on ebooks. This is consistent with the format of our dataset, which exclusively contains ebooks. Print formats such as paperback and hardcover are considered secondary and are typically estimated by applying standard multipliers—1.5× for paperback over ebook, and an additional 1.5× for hardcover over paperback. For our purposes we will keep the price within the price bound we develop.

After cleaning the dataset to remove entries missing either price or page count, we obtained summary statistics shown in Table 1.

Statistic	Pages	Price ($CAD)
count	82.00	82.00
mean	553.34	79.22
std	288.75	66.19
min	91.00	8.99
25%	355.50	43.02
50%	481.50	55.99
75%	668.75	96.40
max	1488.00	314.94

TABLE 1. Descriptive statistics of page count and price for programming books retrieved from Google Books API

While the table provides a statistical overview, further insight is gained through visualization. Figure 1 shows a scatter plot of price versus page count distribution. A notable concentration of titles lies within the 200–400 page range, which we expect our publications in the collective to target.

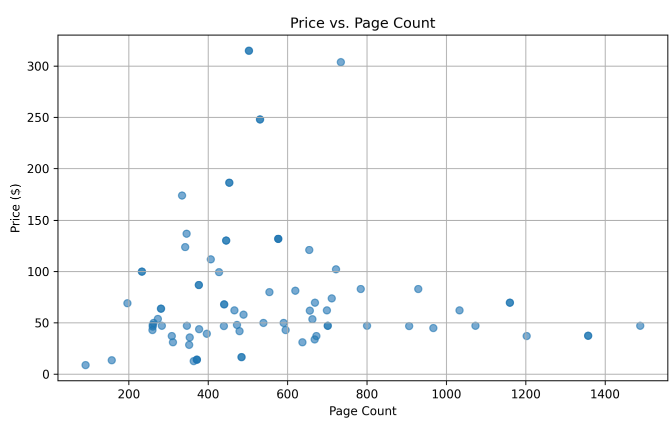

FIGURE 1. Scatter Plot of Price vs. Page Count

As illustrated in Figure 1, books within the 200–400 page range cluster around a price point of approximately \$50. This suggests that \$50 may serve as an upper bound for our formats, while pricing could reasonably target a midpoint range of \$25–30 to improve affordability.

The range chosen can additionally be supported by the 2024 Canadian Book Consumer Study [1] which found 53% of Canadians purchasing new books in the price range of \$1-49.

2. The Optimization Problem

In the context of multi-platform publishing, determining optimal pricing across these various platforms and the formats they support (eg. Ebook, Paperback, Hardcover) requires a balance between the royalties earned per unit, format differentiation such as how ebooks won't have a print cost compared to paperback or hardcover which effects the author's earnings, and the affordability of the publication to the consumer or reader.

Let there be n publishing formats/platforms where each associated with a unit price $p \in [p_{\min}, p_{\max}]$, a corresponding royalty rate $r_i \in (0,1)$ that determines the revenue earned per unit sold: $r_i p$, and lastly the platform's market share m_i. To ensure consistency and flexibility, we express each price as a normalized variable $x_i \in (0,1)$, such that:

$$p(x_i) = p_{\min} + x_i(p_{\max} - p_{\min}) \tag{1}$$

This formulation allows the optimization to occur over the unit interval, while still mapping to actual price values within a global price bound.

The primary objective of our problem is to maximize the total expected royalty across all platforms, while maintaining a balance in the price to maintain a focus on affordability, accessability and variability in price between each platform. The objective function is defined in a reward and penalty form, where the *reward* is the expected total royalty earned from all platforms while also considering the market share, and the *penalty* term is the negative entropy of the price in all platforms.

$$\max_{\mathrm{x} \in [0,1]^{\mathrm{n}}} \quad \left[\sum_{i=1}^{n} p(x_i) \cdot \tau(r_i, m_i) - \lambda_p \sum_{i=1}^{n} p(x_i) \ln(p(x_i)) \right] \tag{2}$$

Where $\tau(r_i, m_i)$ is a logit function defined as:

$$\begin{aligned} \tau(r_i, m_i) &= \frac{e^{U(r_i, m_i)}}{\sum_j e^{U(r_j, m_j)}} \\ U(r_i, m_i) &= \beta_1 r_i + \beta_2 m_i \end{aligned} \tag{3}$$

The logit function τ uses a utility variable U which is used to describe the price sensitivity based on its royalty rate and the market share that are balanced with β_1, β_2.

Equivalently, this can be posed as a minimization problem that we can use in numerical optimization techniques:

$$\min_{\mathrm{x}\in[0,1]^{\mathrm{n}}} \left[-\sum_{i=1}^{n} p(x_i)\cdot\tau(r_i,m_i)+\lambda_p\sum_{i=1}^{n} p(x_i)\ln(p(x_i))\right] \tag{4}$$

Here, the parameter $\lambda_p \geq 0$ governs the trade-off between maximizing royalties and discouraging price inflation. A higher λ_p places greater emphasis on reducing the overall price, thereby improving affordability.

Constraints

To ensure logical structure and consistency in pricing and royalty assignment, we impose two key sets of contraints onto our problem:

1. **Monotocity in Price Levels:** To prevent illogical pricing where a format perceived to be of lower value is priced above a higher-tier format, we require strictly increasing normalized price levels:
$$x_{i+1}-x_i \geq \delta \quad \forall i=1,...,n-1 \tag{5}$$
2. **Monotocity in Royalty-per-Unit:** To incentivize distribution through high-royalty platforms and maintain economic alignment, we require that the effective royalty earned per unit decreases across formats of decreasing royalty rate:
$$r_i p(x_i) \geq r_{i+1}p(x_{i+1})+\varepsilon \quad \forall i=1,...,n-1 \tag{6}$$

Initialization Strategy

To help acheive convergence faster and add bias to the optimization towards realistic solutions, we propose a smart initialization based on the ordinal rank of the royalty rate. Let $R(r_i)$ denote the rank of format i's royalty rate among all formats, with rank 0 being the highest. Let U denote the number of unique royalty tiers, then the initial guess for each normalized price is given by:

$$x_i^{(0)} = \frac{R(r_i)}{U-1} \tag{7}$$

This initialization method places formats with higher royalty rates closer to the lower bound of the price range, thus having our model bias towards our affordability goal.

3. Applying the Model to Determine Minimum Set Prices

To solve the royalty-constrained pricing optimization problem, we employ two gradient-based nonlinear optimization methods: Sequential Least Squares Programming (SLSQP) and the Trust Region Constrained (trust-constr) algorithm. These methods are well-suited for problems that involve smooth objective functions and nonlinear inequality constraints—characteristics inherent to our pricing model, which simultaneously seeks to maximize royalties, enforce monotonicity, and preserve pricing fairness.

The SLSQP algorithm, originally proposed by Kraft (1988) [2], is a quasi-Newton method that handles both equality and inequality constraints efficiently. It updates the solution iteratively using sequential quadratic programming steps, making it particularly suitable for small- to medium-scale problems with smooth constraint structure.

By contrast, the trust-region constrained method (Byrd, Schnabel, and Shultz, 1987) [3] provides a more robust approach by solving a local approximation of the problem within a dynamically updated region where the model is trusted to be accurate. It incorporates both first- and second-order derivative information (Jacobian and Hessian) and uses barrier or merit functions to handle inequality constraints. This makes it more stable for tightly coupled constraint systems or cases where convergence is sensitive to initial guesses or step sizes.

We now apply the model to determine optimal pricing across self-publishing platforms used by the MoKa Reads Collective. The selected platforms, with corresponding formats and royalty rates, are shown below:

Platform	Format	Royalty Rate
MoKa Reads	Ebook	92.5%
Leanpub	Ebook	80%
Kobo/Google Books/B&N	Ebook	70%
KDP	Paperback	60%
B&N Print	Paperback	55%
KDP	Ebook (≥ $9.99)	35%

Note: The 35% rate for KDP eBooks arises because our prices exceed the $9.99 cap for eligibility under their 70% royalty program [4]. For print formats, royalties reflect author revenue before printing costs, reinforcing our interpretation of these as minimum set prices. Ebook prices, in contrast, are profit-aligned.

The following parameters are used in our optimization procedure:

Parameter	Value
$(p_{\min}, p_{\max})$	$(8.99, 50)$
δ	0.05
ε	0.25
λ_p	0.05
r	$[0.925, 0.8, 0.7, 0.6, 0.55]$

Table 3. Parameters for SLSQP and TRCP solvers

Optimization Results

We ran both SLSQP and Trust-Region solvers using the same problem formulation and constraints. Remarkably, both methods converge to identical price vectors, showing high consistency and validating the model's numerical stability.

Format	Price(SLSQP)	Royalty-per-Unit (SLSQP)	Price (Trust)	Royalty-per-Unit (Trust)
Format 1	18.68	17.28	18.69	17.28
Format 2	21.29	17.03	21.29	17.03
Format 3	23.98	16.78	23.98	16.78
Format 4	27.56	16.53	27.56	16.53
Format 5	29.61	16.28	29.61	16.28

Table 4. Comparison of optimal prices and royalties obtained using SLSQP and Trust-Region Constrained methods for multi-format royalty-constrained pricing.

The results validate that our optimization framework yields price structures that are logically consistent, economically justified, and equitably aligned across publishing platforms. By assigning more affordable prices to higher-royalty platforms, the model simultaneously promotes reader accessibility and ensures author sustainability. This approach offers a transparent, data-driven methodology for principled price determination under practical royalty constraints. Ultimately, the computed values establish the minimum set prices to be adopted for MoKa Reads Collective's forthcoming publications.

4. Conclusion

This paper presented a principled pricing optimization framework designed to balance reader affordability with author compensation under platform-specific royalty constraints. Grounded in the mission of the MoKa Reads Collective, our model uses nonlinear optimization with monotonicity and royalty-based constraints to generate fair, data-driven prices across multiple formats.

Using SLSQP and trust-region methods, we demonstrated that the model consistently produces logically ordered and economically aligned prices, rewarding high-royalty platforms with greater affordability. The resulting minimum set prices offer a transparent and sustainable foundation for future MoKa Reads publications.

Appendix

A. Pseudo-Code.

```
Inputs:
    n           ← number of publishing formats
    r[1..n]     ← royalty rates per format
    p_min       ← global minimum price
    p_max       ← global maximum price
    λ_p         ← price penalty weight
    δ           ← minimum price spacing (normalized)
    ε           ← minimum royalty-per-unit spacing

Initialize:
    For each format i = 1 to n:
        Assign normalized price variable x_i ∈ [0, 1]
        Set initial guess x_i^(0) ← rank(r_i) / (R - 1)

Define:
    p_i(x_i)     ← p_min + x_i * (p_max - p_min)
    objective(x_i) ← ( -∑ r_i * p_i(x_i) + λ_p * (∑ p_i(x_i))^2 ) / n

Subject to constraints:
  For i = 1 to n - 1:
    x_{i+1} - x_i ≥ δ                                [Price ordering]
    r_i * p_i(x_i) ≥ r_{i+1} * p_{i+1}(x_{i+1}) + ε  [Royalty ordering]
    For all i:
        0 ≤ x_i ≤ 1                                  [Normalized bounds]

Solve:
  Use a constrained optimization algorithm (e.g., SLSQP or Trust-Region
Constrained) to find x* = argmin objective(x) subject to constraints

Output:
    For each i:
        Price:   p_i = p_min + x_i * (p_max - p_min)
        Royalty: r_i * p_i
    Report:
        Total Price   = ∑ p_i
        Total Royalty = ∑ r_i * p_i
```

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