E-Commerce Using FAIR: A Fiscal Algorithm for Inflation and Retail

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Abstract

E-commerce pricing faces increasing challenges due to inflationary pressures and shifting economic conditions, prompting a need for innovative solutions that promote fairness for vendors and consumers. This paper introduces the FAIR (Fiscal Algorithm for Inflation and Retail) algorithm, a dynamic pricing solution that curbs price gouging by integrating real-time inflation and interest rates. The algorithm calculates fair prices by factoring in production costs, overhead, shipping, and current economic data, ensuring pricing flexibility for vendors. Vendor rankings are determined based on alignment with FAIR-calculated prices and competitive positioning, incentivizing reasonable pricing behavior. By balancing profitability, competitiveness, and fairness, the FAIR algorithm promotes market stability, strengthens consumer trust, and offers a scalable solution to achieve equilibrium in fluctuating economic environments.

1. Introduction

1.1. Overview of E-Commerce Pricing Challenges

The rapid expansion of e-commerce has introduced a wide range of products and sellers into a global marketplace, making it easy for consumers to access many choices. However, this diversity has also led to significant pricing challenges. Vendors often price their products independently, resulting in wide price disparities for similar items. Economic factors such as inflation further complicate the landscape, affecting consumer purchasing power and vendor costs. Sellers typically adjust prices to maintain profitability, but without consistent regulation, these changes may lead to inflation that exceeds fundamental economic necessity.

Inflationary pressures can be challenging to distinguish from intentional price increases. This often leads to systemic price rises, making it hard for consumers to gauge whether they're paying a fair price. These issues became even more pronounced during events like the COVID-19 pandemic as vendors raised prices drastically, citing shipping delays and shortages. Once these issues were resolved, many prices remained high, leading to accusations of price gouging. Such practices erode consumer trust and create an imbalance where consumers pay inflated prices without objective justification.

1.2. Motivation for the FAIR Algorithm in E-Commerce

In response to these challenges, this paper introduces the Fiscal Algorithm for Inflation and Retail (FAIR), designed to create a transparent and equitable pricing framework for e-commerce platforms. FAIR aims to help vendors set fair prices for consumers while maintaining their ability to choose their pricing strategy freely. Unlike traditional consensus-based pricing models, FAIR adjusts dynamically for inflation and interest rates, ensuring that vendors' prices reflect current market conditions.

FAIR introduces a unique ranking mechanism where vendors who set prices in alignment with a calculated FAIR price—based on real-time economic factors such as inflation and production costs—are rewarded with increased product visibility on the platform. This method will incentivize vendors to avoid excessive markups while still allowing for profit margins. Rather than penalizing sellers for seeking higher profits, the algorithm only reduces visibility for prices that significantly deviate from fair market value without justification. In essence, FAIR provides a balanced system that rewards competitive pricing and discourages price gouging while keeping inflationary impacts in check.

1.3. Objectives of the Pricing Algorithm

The primary goal of the FAIR algorithm is to establish a more balanced and competitive pricing ecosystem within e-commerce platforms, benefiting both consumers and vendors. The specific objectives of the FAIR algorithm are as follows:

- **Promoting Competitive and Fair Pricing:** By ranking vendors based on how closely their prices align with the calculated FAIR price, the algorithm encourages competitive pricing without penalizing fair profit margins.

- **Incorporating Inflation and Interest Adjustments:** The algorithm dynamically adjusts base prices for inflation and interest rates, ensuring that prices reflect real-time economic conditions while protecting vendors from fluctuating interest rates.

- **Balancing Vendor Flexibility with Fair Competition:** Vendors retain complete control over their pricing decisions, but are encouraged through the incentives to price their products competitively to maintain visibility on the platform. Prices significantly above the FAIR price reduce visibility, but do not penalize vendors with lower input (manufacturing, overhead, shipping) costs.

- **Building Consumer Trust:** By ensuring transparent and reasonable pricing, the algorithm builds consumer confidence, creating a marketplace perceived as fair and reliable.

2. Literature Review

2.1. Existing Pricing Models in E-Commerce

E-commerce platforms employ various pricing strategies to remain competitive. Traditional models like cost-plus and value-based pricing have been foundational, but recent developments favor more dynamic approaches like algorithmic pricing [1]. Algorithmic pricing, or dynamic pricing, involves setting prices using algorithms that respond to competitor pricing, demand, and other factors. On platforms like Amazon, where competition is fierce and pricing is a critical factor in winning the Buy Box, algorithmic pricing plays a crucial role in shaping marketplace dynamics [1].

Pricing algorithms have advanced significantly, transitioning from basic rule-based models to more complex AI-driven systems [3]. AI-powered algorithms can learn from past pricing decisions and adjust accordingly [3]. Adopting algorithmic pricing tools has increased profit margins, particularly in competitive markets, suggesting reduced competition [3].

An increasing number of companies, especially in travel, retail, and entertainment industries, have adopted algorithmic pricing to capitalize on the vast availability of digital data and technological advancements [3]. These systems automate the process of price-setting, allowing businesses to react to real-time market dynamics and adjust prices based on predefined rules and constraints [3].

Research presented in a bibliometric analysis highlights that algorithmic pricing allows platforms to react in real-time to market conditions, improving vendor competitiveness and optimizing sale outcomes. However, this model can also exacerbate market inequalities by allowing vendors with advanced pricing algorithms to outperform those relying on static or less sophisticated approaches [2].

2.2. Price Gouging and Competitive Pricing

Algorithmic pricing can help vendors remain competitive, but can also lead to price gouging, particularly in times of high demand or scarcity. Reports show that competing algorithms can result in inflated prices when multiple vendors use similar tools to adjust their pricing, sometimes leading to unintended escalations [1]. The interaction of multiple algorithms has, in some cases, pushed prices to unreasonable extremes. In one well-documented case, the cost of a used textbook on Amazon escalated to over $23 million due to competing dynamic pricing algorithms [1].

Dynamic pricing has also faced criticism for contributing to price gouging, especially in high demand or crises. For instance, companies like Uber have faced backlash for significantly raising prices during emergencies such as natural disasters, highlighting fairness concerns surrounding such algorithms [3]. This can lead to perceptions of unfairness, as consumers may feel charged more based on their willingness to pay, resulting in accusations of price discrimination [2].

Moreover, algorithms can unintentionally encourage collusive pricing by rewarding companies that comply with price agreements and penalizing those that lower prices [5]. This can lead to coordinated pricing structures, similar to hub-and-spoke collusion, primarily when multiple businesses in the same market use the same algorithm [5]. Low market transparency can force consumers to pay higher prices for essential goods, even when supply remains steady. Therefore, fair pricing models considering external factors, like inflation, are essential for balancing vendor profitability and consumer satisfaction [2].

2.3. Impact of Market Trends on Pricing Strategies

The success of e-commerce platforms is closely tied to their ability to adapt to market trends, particularly inflation and demand shifts. Algorithmic pricing allows vendors to adjust quickly to these changes. On Amazon, sellers using algorithms to monitor competitors' prices often experience price volatility, significantly affecting customer satisfaction and sales volume [1]. Rapid price fluctuations observed in many e-commerce environments can discourage consumers, who may perceive such volatility as a lack of price stability [1].

Dynamic pricing helps companies respond to market shifts by using real-time data on supply, demand, and competitor pricing [3]. However, frequent price changes can reduce consumer trust, especially when lacking transparency [2]. In some cases, algorithmic pricing has enabled businesses to react efficiently to market fluctuations, but the risk of market-wide price inflation remains when many firms adopt similar strategies [3].

Algorithmic pricing tools, particularly those that integrate inflation trends and competitor data, provide a more sustainable approach. They ensure businesses can react to immediate market pressures while supporting long-term pricing stability [2].

2.4. Algorithmic Pricing in Online Marketplaces

Algorithmic pricing has expanded beyond large retailers to smaller vendors, thanks to accessible tools like Amazon Marketplace Web Services (MWS). These tools enable small and medium sized enterprises (SMEs) to employ advanced pricing strategies. Research shows that algorithmic pricing is particularly effective in increasing sales volume and winning the Buy Box, a critical success factor in marketplaces [1]. However, this practice can also exacerbate the disparity between algorithmic and non-algorithmic sellers, often making it difficult for the latter to compete effectively [1].

In smaller markets, where all businesses adopt algorithmic pricing, margins have been found to increase by as much as 40% [5]. While algorithmic pricing can boost margins, it may also raise concerns about anti-competitive behavior, as algorithms react quickly to competitors' price changes, sometimes resulting in unintentional price coordination [5]. Although algorithmic pricing helps companies frequently update and optimize prices, there remains a risk of market-wide price inflation when many firms employ similar strategies [3].

Furthermore, dynamic pricing strategies can impact not just prices, but also customer behavior and market positioning, leading to both opportunities and challenges for businesses seeking to maintain competitiveness in increasingly algorithm-driven marketplaces [2].

3. Algorithm Design

The goal of the FAIR algorithm is to dynamically adjust for inflation and interest rates while allowing vendors to maintain flexibility in pricing. Unlike traditional consensus-based models, which average the prices in the market, this algorithm emphasizes cost transparency, inflation and interest adjustments, and competitive ranking to incentivize vendors to keep prices fair.

3.1. Overview of the Pricing Model

The model offers transparency and fairness to vendors and consumers. The algorithm calculates a suggested FAIR price based on the seller's documented costs. It adjusts for inflation and interest rates in real-time using APIs, ensuring that the price reflects current economic conditions. Vendors are ranked based on how closely their prices align with the price deviation from the FAIR price, and products with lower deviations receive better visibility on the platform.

Rather than setting a consensus-based price, the algorithm generates a base price specific to each vendor's cost structure, ensuring the suggested FAIR price is grounded in actual costs. Vendors who choose to price significantly above this recommendation may still do so, but their rank and visibility will decrease, providing a natural incentive to remain competitive.

3.2. Vendor Flexibility and Price Setting

While the algorithm suggests a FAIR price based on economic data (i.e., the base price adjusted for inflation and interest rates), vendors retain the flexibility to set their prices. The vendor can either accept the suggested FAIR price or input a custom price based on their desired profit margin. However, vendor rankings are determined by how closely their price aligns with the FAIR price before adding the profit margin.

This ranking mechanism ensures that vendors can still aim for higher profits if they wish, but it also encourages them to maintain reasonable prices to ensure higher visibility. The system balances

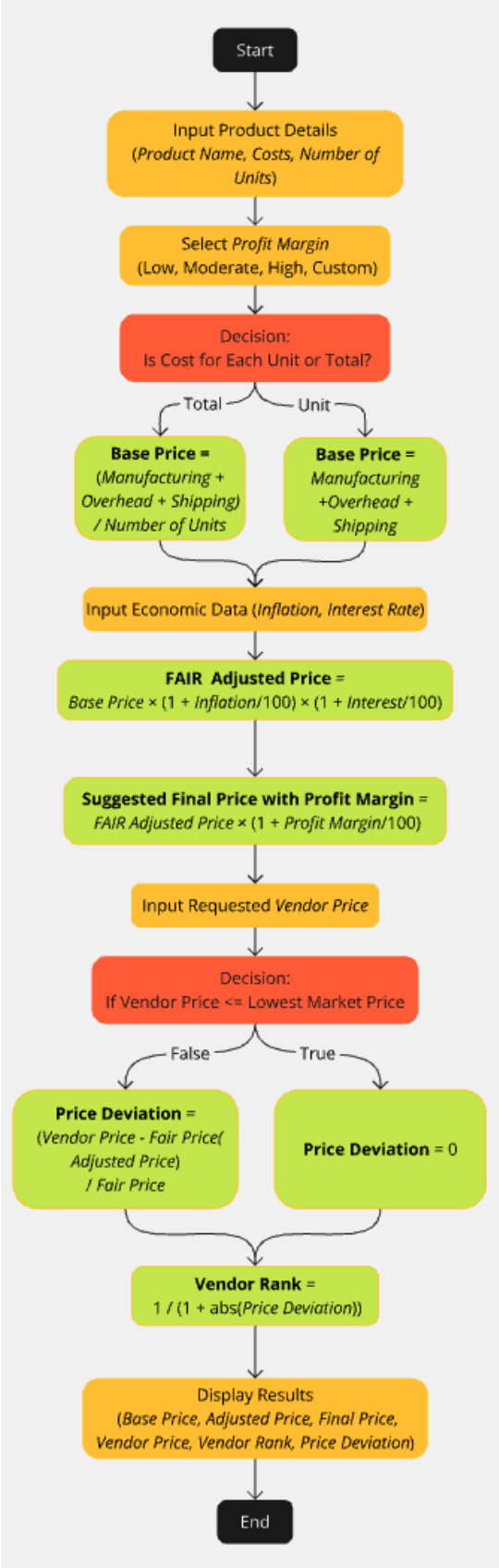

Figure 1. Flowchart of the FAIR Algorithm Workflow

profitability and competitiveness by promoting transparency while maintaining flexibility for vendors to adjust their pricing strategies.

3.3. Key Components of the Algorithm

The flow chart in Figure 1 shows the FAIR components at work. These core components of the algorithm include:

3.3.1. Base Price Calculation: The Base Price Calculation (BPC) forms the foundation of the pricing model. It is derived from the vendor's input of manufacturing costs, overhead costs, and shipping costs. Each seller must upload supporting documentation for these values to ensure transparency and accuracy. This ensures that the suggested FAIR price reflects the actual costs incurred by the vendor, providing a fair starting point for price setting. Vendors have the option to input costs for an entire stock of the same item or for a single unit.

For Total Stock:

$$BPC = \frac{\text{Production Costs} + \text{Overhead Costs} + \text{Shipping Costs}}{\text{Number of Units}}$$

For Individual Unit Pricing:

$$BPC = \text{Production Costs} + \text{Overhead Costs} + \text{Shipping Costs}$$

3.3.2. Overhead and Shipping Costs: Overhead and shipping costs vary significantly by region, supplier, and product type. Vendors must submit documentation to justify their overhead and shipping expenses, which are factored into the base price calculation. The algorithm considers the variance in these costs, ensuring that products in high-overhead or high-shipping-cost areas are not unfairly penalized. By verifying the overhead and shipping costs with documents, the algorithm creates an accurate base price and eliminates the risk of artificially inflated prices. Vendors are encouraged to keep their overhead and shipping costs reasonable to maintain competitiveness.

3.3.3. Interest and Inflation Adjustments: To ensure that the suggested price reflects real-time economic conditions, the algorithm adjusts the base price using the latest inflation and interest rate data. However, interest rates are only applied during the initial calculation of the base price, as this reflects the actual cost incurred by the vendor at the time of purchase or production. For subsequent price adjustments, only inflation rates are applied to account for changes in the purchasing power of money. This ensures that vendors are not unfairly penalized if interest rates decrease after purchase, as their borrowing cost remains constant, while inflation adjustments keep the pricing aligned with the current economic environment.

$$\text{FAIR price} = BPC \times \left(1 + \frac{\text{Dynamic Inflation Rate}}{100}\right) \times \left(1 + \frac{\text{Initial Interest Rate}}{100}\right)$$

3.4. Integration of Market Data and Benchmarking

The platform integrates additional market data, such as industry averages and competitor pricing, to provide further context to vendors. This allows them to benchmark their pricing strategy against market trends and competition. Vendors can see how their product ranks relative to similar products and make informed decisions about their pricing.

3.4.1.Base Price Ranking (BPR): The **Base Price Ranking (BPR)** evaluates the competitiveness of a vendor's price compared to the lowest price in the market. If the vendor's price is lower than or equal to the lowest market price, the algorithm bypasses the price deviation ranking. It assigns the vendor a high rank to reward their competitiveness. If the vendor's price exceeds the lowest market price, the price deviation formula calculates their ranking based on the *FAIR price*.

The ranking mechanism is as follows:

$$\text{Rank} = \begin{cases} 1 & \text{if Vendor Price} \leq \text{Lowest Market Price} \\ \frac{1}{1+|PD|} & \text{if Vendor Price} > \text{Lowest Market Price} \end{cases}$$

Where PD (Price Deviation) is calculated as:

$$PD = \frac{\text{Vendor Price} - \text{FAIR Price}}{\text{FAIR Price}} \times 100$$

This ranking system ensures that vendors who offer lower prices than the market are rewarded with better visibility, while those who price above the lowest market price are ranked according to their deviation from the FAIR price.

In this formula:

- If the vendor's price is less than or equal to the **Lowest Market Price**, they receive the maximum ranking (Rank = 1), bypassing the price deviation calculation. This ensures that vendors offering the most competitive prices are rewarded with better visibility.

- If the vendor's price is higher than the **Lowest Market Price**, the ranking decreases based on how much higher the price is compared to the *FAIR Price*. The greater the price deviation from the *FAIR Price***,** the lower the ranking.

4. Price Deviation and Vendor Ranking Mechanism

This section describes how price deviation is calculated and how it impacts the ranking of vendors on the platform. The algorithm is designed to promote competitive pricing by adjusting vendor visibility based on their pricing decisions relative to the platform's fair price or the lowest market price, if available.

4.1. Calculation of Price Deviation (PD)

Price Deviation (PD) is a key metric used to evaluate how closely a vendor's price aligns with the algorithmically calculated *fair price* (the base price adjusted for inflation and interest rates) or the lowest market price. The formula for calculating Price Deviation (PD) is:

$$PD = \frac{\text{Vendor Price} - \text{Fair Price}}{\text{Fair Price}} \times 100$$

A positive PD indicates that the vendor's price is above the fair price, while a negative PD means the vendor's price is below the fair price. The vendor's ranking is influenced by how close their price is to the fair price, unless the vendor has set a price below the lowest market price. In that case, no penalty will be applied, and the vendor will be rewarded for offering a competitive price.

The vendor's ranking is primarily influenced by how close their price is to the FAIR price, ensuring fair competition while accounting for the potential benefits of offering lower prices compared to the market.

4.2. Ranking Vendors Based on Price Deviation

Their deviation from the FAIR price determines the vendor's rank. To avoid penalizing vendors who price their products at a competitive or lower rate, the algorithm accounts for cases like these. If a vendor prices their product below the market value price, the price deviation, now set at PD = 0, will not negatively impact their ranking. In fact, the vendor will receive the maximum ranking possible. However, vendors who price significantly above the FAIR price will reduce their ranking based on the magnitude of the deviation and density of that product in the market.

The formula for calculating vendor rank is as follows:

$$\text{Vendor Rank} = \frac{1}{1 + |PD|}$$

Where PD is the Price Deviation from the FAIR price.

By focusing on price deviation from the FAIR price, the algorithm promotes fairness and encourages vendors to maintain competitive pricing strategies.

4.3. Thresholds for Visibility Boost

The platform uses specific thresholds to determine which vendors receive a visibility boost based on their pricing alignment with the FAIR price. Vendors whose price deviations fall within a predefined threshold (e.g., ±5% of the FAIR price) are eligible for a visibility boost, which increases their product's prominence in search results.

The visibility boost criteria include the following:

- **PD Threshold:** Vendors with a price deviation (PD) within ±5% of the FAIR price will receive a visibility boost. This threshold is dynamically adjusted based on market conditions and consumer behavior.

- **Consistency in Competitive Pricing:** Vendors who consistently price their products within this range over time will gain additional visibility rewards, further promoting fair and competitive pricing on the platform.

This approach encourages vendors to price competitively. Those who maintain their prices close to the FAIR price will benefit from increased visibility, leading to better sales opportunities.

4.4.Example Scenario: Vendor Price Ranking

Consider a scenario, shown in Figure 2, where a vendor sells a product called "Unique Item." After calculating production costs, overhead, and shipping costs, the algorithm computes the following values:

- Base price: $38.00

- Inflation and Interest Adjusted Price (FAIR price): $42.07

- Final Price with Profit Margin (50% margin): $63.10

The vendor chooses to set their price at $50, which leads to the following results:

- Vendor Price: $50.00

- Price Deviation (PD): 18.86% (Vendor price is higher than the FAIR price)

- Vendor Rank: 5.30 (calculated based on the deviation from the FAIR price)

Since the vendor's price exceeds the FAIR price by 18.86%, their ranking decreases accordingly. While their price is still competitive and within a reasonable range, the deviation impacts their visibility on the platform. This ranking system rewards vendors who offer competitive or lower prices relative to the FAIR price.

Base Price	$38.00
Inflation & Interest Adjusted Price (Fair Price)	$42.07
Final Price with Profit Margin	$63.10
Vendor Price	$50.00
Vendor Rank	5.30
Price Deviation (%)	18.86%

Figure 2. FAIR Algorithm Implementation

5. Implementation of the Algorithm

This section outlines the technical implementation of the FAIR (Fiscal Algorithm for Inflation and Retail) system, discussing its architecture, integration with real-time economic data APIs, the workflow of the pricing algorithm, and considerations for scalability and real-time updates.

5.1. Architecture Overview

The architecture of the FAIR system is designed with modular components that enable flexibility, scalability, and real-time data processing. The system consists of three main layers:

- **Data Input Layer**: This layer collects and processes data from vendors, including production costs, overhead costs, and shipping costs. It also fetches external economic data such as inflation and interest rates via APIs.

- **Algorithm Processing Layer:** At the system's core, the pricing algorithm processes the input data, calculates the dynamic FAIR price, and applies real-time adjustments based on inflation and interest rates.

- **Presentation Layer:** This layer presents the final suggested FAIR price, vendor rankings, and visibility adjustments to the seller and consumers. The presentation layer also handles seller feedback and pricing modifications.

The system is built using a microservices architecture, which allows different components to operate independently, ensuring ease of maintenance and updates.

5.2. API Integration for Economic Data

To dynamically adjust prices based on real-time economic factors, the FAIR algorithm integrates with various external APIs that provide inflation and interest rates data. These APIs are regularly queried (e.g., every three months) to ensure that the pricing algorithm reflects the latest economic conditions. The following APIs are utilized in the system:

- **Inflation Data API:** Provides real-time inflation rates from trusted financial institutions.
- **Interest Rate API:** Delivers updated interest rate information from central banks and financial authorities.

These APIs ensure that the FAIR price remains accurate and transparent, reflecting current economic conditions while allowing vendors to adjust their prices accordingly.

5.3. Workflow of the Pricing Algorithm

The pricing algorithm workflow follows a structured process to compute the suggested FAIR price and adjust product visibility based on price deviation. The steps involved are:

1. **Vendor Data Input:** The vendor submits details about the product, including production, overhead, and shipping costs, along with supporting documents.
2. **API Data Fetching:** The system fetches current inflation and interest rates from external APIs.
3. **Base Price Calculation**: The algorithm calculates the dynamic base price (FAIR price) using the vendor's data and external economic conditions.
4. **Final Price Adjustment:** The seller can adjust the final price based on their desired profit margin, which may impact their product's rank.
5. **Price Deviation Calculation:** The price deviation (PD) is calculated as the difference between the vendor's final price and the suggested FAIR price.
6. **Ranking and Visibility Update:** The algorithm ranks products based on PD and adjusts their visibility on the platform. Sellers with lower deviations receive better visibility.

6. Python Code Implementation

The following Python code implements the FAIR algorithm for e-commerce pricing. The code calculates the base price, adjusts for inflation and interest rates, and ranks vendors based on price deviation from the FAIR price.

Found in the official paper.

7. Discussion

7.1. Challenges and Limitations

While the FAIR algorithm offers a dynamic pricing solution, it does come with certain challenges:

- **Inflation and Interest Rate Fluctuations:** Rapid changes in inflation or interest rates could create challenges for vendors who have already set prices. The algorithm accounts for this by applying interest rates only during initial price calculations and focusing on inflation for subsequent updates.
- **Handling Market Anomalies:** In cases where a vendor receives a good deal below market cost, the system adjusts ranking logic to prevent penalizing such vendors, as discussed earlier. However, market anomalies need ongoing monitoring to ensure the algorithm adapts appropriately.

7.2. Future Enhancements

Future versions of the FAIR algorithm could incorporate additional improvements:

- **Detailed Vendor Insights:** Vendors could be given access to more granular feedback on their pricing strategies compared to market data.
- **International Adaptation:** The algorithm could adapt to international markets by incorporating country-specific inflation rates and economic data to provide localized pricing.
- **Consumer Behavior Analysis:** Expanding the algorithm to analyze complex consumer behavior, such as seasonal trends, could optimize the ranking system.

7.3. API Integration for FAIR Algorithm

A potential enhancement to extend the usability of the FAIR algorithm would be the development of

an API that e-commerce platforms can integrate. The API would allow vendors to fetch dynamic pricing recommendations and rankings in real time based on inflation rates and market trends.
Key features of the API include:

- Real-time inflation and interest rate adjustments through API calls to external financial data providers.
- Vendor submission of cost structure (base price, overhead, shipping costs) through standardized API endpoints.
- Dynamic ranking updates based on vendor prices compared to the calculated FAIR price and real-time market conditions.

8. Conclusion

The FAIR algorithm offers an innovative solution to dynamic e-commerce pricing by accounting for real-time economic factors such as inflation and interest rates. The system promotes fair competition, vendor flexibility, and consumer transparency, leading to greater consumer trust and market efficiency.

8.1. Summary of Benefits

The key benefits of the FAIR algorithm are:

- **Fair Competition:** Vendors are ranked based on adherence to a fair pricing model, reducing the risk of price gouging and promoting a healthier marketplace.
- **Dynamic Pricing Adjustments:** By adjusting prices based on inflation and interest rates, the algorithm ensures pricing remains reflective of current economic conditions.
- **Vendor Flexibility:** Vendors retain the ability to set their prices while being incentivized to stay within a reasonable range to maintain visibility and competitiveness.
- **Improved Consumer Trust:** Transparency in the pricing process enhances consumer trust, leading to greater satisfaction and long-term loyalty.

The FAIR algorithm represents a step forward in fair, transparent, and adaptive e-commerce pricing strategies. Future work will enhance scalability, international applicability, and integration with consumer behavior analytics.

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