An Economic and Algorithmic Study on the Price Spread and Income Variability among Street Vendors: Empirical Evidence from Paravai and Mattuthavani Vegetable Markets, Madurai

A. Marimuthu

Head & Associate Professor, Department of Economics and Research in Economics, Government Arts College, Melur, Madurai, Tamil Nadu, India

Email: dramarimuthu@gmail.com

Abstract

The study carries out an empirical and algorithmic examination of the price spread, marketing efficiency, and daily variations in income amongst vegetable street vendors in the Madurai district of Tamil Nadu. It was carried out over a four-month span from June 2026 to September 2026, with 60 active street vendors being sampled (30 from the Paravai wholesale market centre and 30 from the Mattuthavani urban retail market) via structured primary field interviews. The economic analysis shows that multiple intermediary supply channels result in a large marketing price spread of 50.0% (amounting to Rs.20.00 per kg), taking up a major part of the consumer's outlay and reducing the producer's portion of the consumer's money to 50.0%. On the other hand, obtaining goods directly from the Paravai hub lowers the price spread to 42.1% (equivalent to Rs.16.00 per kg) and raises the vendors' net profit margins from Rs.7.50 per kg to Rs.11.00 per kg. The financial volatility analysis indicates a considerable degree of instability in daily net income (with a coefficient of variation of 28.4%) in the sample, this being greatly worsened by physical spoilage losses which amount to an average of Rs.400.00 per day (11.0% of daily gross sales). In order to address these market risks, the daily price data were analysed using time-series predictive algorithms. The Long Short-Term Memory (LSTM) neural network showed better forecasting results (with an RMSE of 2.12 and a MAPE of 4.3%). Simulation based on the algorithms proved that adjusting the time of procurement according to the data reduces perishable waste by 37.4%, increases the mean daily net income of the vendors by 22.2% (raising it from Rs.585.00 to Rs.715.00), and reduces the variation in income to 16.6%. Combining direct procurement networks with the use of mobile algorithmic price forecasting provides an effective approach to stabilising the livelihoods of small vendors.

Keywords: Price Spread, Income Variability, Street Vendors, Algorithmic Price Forecasting, LSTM Neural Network, Marketing Efficiency

Introduction

Urban informal retail markets play a crucial distribution channel for perishable agricultural commodities in South India, benefiting both farming communities and municipal consumers. Paravai wholesale market serves as a significant regional aggregation point for Madurai, whereas, the Mattuthavani integrated market represents a dense urban retail nexus. Vegetable street vendors trading in this ecosystem are exposed to complex market mechanisms influenced by fuel prices, weather events, and supply chain inefficiencies. Between June 2026 and September 2026, seasonal monsoon fluctuations and supply distortions highlighted the economic vulnerabilities of micro-retailers. Price spread the disparity between farm gate prices and final consumer prices remains wide due to multi-tiered intermediary commissions, high transportation overheads, and post-harvest decay losses. Simultaneously, the high degree of daily income variability severely restricts vendors' financial security, exposing them to high-interest informal debt cycles. Whereas digital technology and algorithmic predictive modeling has revolutionized formal supply chain management, informal street vending continues to rely on intuitive procurement. Integrating data-driven forecasting algorithms with empirical economic analysis presents an actionable opportunity to stabilize wholesale pricing, optimize stock procurement, and reduce perishable waste. The analysis of the dual dynamics during the mid-2026 operational window provides fresh empirical evidence on the upgrading of traditional vegetable retail ecosystems.

Statement of the Problem

Vegetable vendors in Paravai and Mattuthavani are characterized by economic insecurity due to unpredictable price spreads and extreme income volatility. Without market forecasts, vendors rely on intuition and often over-buy stock at high morning costs, selling off decayed produce at a significant loss by evening. Multi-tiered intermediary commissions exacerbate this gap, limiting producer returns while inflating consumer costs. Post-harvest decay during the monsoon period further drains working capital. Existing literature overlooks how algorithmic price forecasting can assist informal vendors. This study aims to address these structural gaps to evaluate data-driven solutions for stabilizing vendor earnings and reducing waste.

Objectives of the Study

1. To analyze the price spread and marketing efficiency across major supply channels in Paravai and Mattuthavani vegetable markets using primary empirical survey data.
2. To quantify the extent of daily income variability and post-harvest spoilage losses of street vendors across different scale categories in Madurai.
3. To evaluate the performance of predictive algorithms in forecasting daily wholesale prices to optimize vendor procurement strategies and improve net financial returns.

Review of Literature

Ramasamy and Sundaram (2020) investigated the structural dynamics of urban vegetable marketing chains and market price spreads across primary wholesale hubs in southern Tamil Nadu. Their empirical findings revealed that multi-tiered intermediary networks absorbed nearly 45% to 52% of the ultimate consumer price, heavily depressing the farmgate realization share. The study highlighted the disproportionate risks undertaken by micro-retailers and street vendors in relation to daily transit expenses and stock degradation. They recommended direct sourcing corridors between local producers and street vendors to shrink market friction and improve urban vendor net profit margins. Devi and Kumar (2021) evaluated daily net earnings instability and capital vulnerabilities of informal street vendors in peri-urban fresh produce markets. Utilizing empirical survey metrics, they recorded an income Coefficient of Variation (CV) exceeding 30% driven by uncoordinated morning procurement pricing and unpredictable evening distress sales. The authors identified that over 60% of informal retailers depend on high-interest daily informal loans to finance working capital. The paper emphasized the urgent need for micro-institutional credit lines and localized municipal storage infrastructure to shield daily vendor revenues from severe volatility.

Sharma and Verma (2023) analyzed post-harvest spoilage and perishable waste loss structures within traditional open-air retail markets in South India. Their research established that physical stock decay during monsoon months accounted for direct daily revenue loss of between 10% to 14% of total vendor procurement expenditures. The study concluded that the lack of affordable short-term cold storage forced vendors to liquidate fresh stock at below-cost prices by late evening. They underscored that the introduction of low-cost evaporative cooling units at decentralized retail markets could drastically curtail physical waste and

stabilize daily operating cash flows. Patel and Meena (2024) examined the application of time-series econometric models for short-term price forecasting within regional agricultural assembly markets. By comparing classical ARIMA models with non-linear machine learning algorithms, their empirical results demonstrated that predictive modeling could forecast daily wholesale price shifts with under 8% mean absolute error. The study proved that providing advance wholesale price intelligence directly reduced vendor procurement over-purchasing. They advocated for the integration of algorithmic forecasting tools into public agricultural extension services to enable data-assisted inventory management for small-scale traders. Bhutale et al. (2025) conducted a comprehensive price spread and marketing efficiency assessment across primary, secondary, and direct perishable commodity supply channels. Their comparative findings showed that direct channel sourcing significantly reduced total marketing price spread from 50% down to 38%, while expanding producer revenue shares and vendor profit margins. The authors observed that commission agents in secondary wholesale markets exercise disproportionate pricing power. The research concluded that municipal market reforms promoting direct producer-to-vendor trade hubs were critical to fostering equitable price distribution across perishable agricultural value chains.

Anand and Selvaraj (2026) explored deep-learning applications (including LSTM networks) for real-time demand and price forecasting within informal urban vegetable markets. Their field interventions in municipal markets demonstrated that artificial intelligence-driven price alert systems achieved superior directional accuracy (85%) compared to traditional intuitive procurement. The empirical simulation confirmed that algorithm-guided stock purchasing reduced vendor perishable waste by over 35% while increasing average net daily incomes by 20%. The study established that mobile-delivered algorithmic insights present a transformative strategy for mitigating economic vulnerability among micro-street vendors.

Methodology

Sampling Framework: A multi-stage random sampling method was used to select 60 street vendors (n=30 Paravai, n=30 Mattuthavani) in Madurai for primary data collection.

Data Collection Period: Empirical data was gathered through structured interview schedules administered daily to vegetable vendors over four months, spanning from June 2026 to September 2026.

Price Spread Estimation: Price spread was evaluated by subtracting producer prices from final consumer prices, accounting for intermediary margins, transportation costs, and retail operational overheads.

Income Variability Analysis: Vendor income instability was quantified using mean net earnings, standard deviation, and Coefficient of Variation (text CV) calculations to measure daily revenue fluctuations.

Algorithmic Predictive Modeling: Daily price data was trained on ARIMA, Random Forest, and LSTM algorithms to evaluate forecasting accuracy (RMSE, MAPE) for optimizing vendor stock procurement.



Results and Discussion

Socio-Demographic Profile and Operational Scale of Vendors

To understand the baseline economic capacity and vulnerabilities of the vendors, socio-demographic indicators were recorded across both market clusters (N = 60).

Table 1: Socio – Demographic and Operational Profile of Sample Vendors (N = 60)

Parameter	Category	Paravai (n=30)	Mattuthavani (n=30)	Total / Average (N=60)	Percentage
Gender	Male	18	14	32	53.3
	Female	12	16	28	46.7
Age Group	18–35 Years	8	6	14	23.3
	36–50 Years	15	17	32	53.3
	> 50 Years	7	7	14	23.3
Vending Experience	< 5 Years	5	4	9	15.0
	5–15 Years	19	18	37	61.7
	> 15 Years	6	8	14	23.3
Daily Capital (Rs.)	< Rs.2,000	12	8	20	33.3
	Rs.2,000 – Rs.4,000	14	16	30	50.0
	> Rs.4,000	4	6	10	16.7

Source: Survey data.

This table 1 reveals that 53.3% of vendors belong to the middle age bracket (36–50 years), reflecting that street vending is a primary household livelihood rather than temporary employment. Women comprise 46.7% of the sample, with a higher presence in Mattuthavani due to localized retail customer density. Half of the vendors (50.0%) operate on daily working capital between Rs.2,000 and Rs.4,000, relying primarily on informal morning credit from local money lenders or commission agents.

Price Spread Analysis across Supply Channels

Price spread measures market efficiency across the supply chain. Two primary channels were identified:

- **Channel I:** Producer → Wholesaler / Commission Agent → Street Vendor → Consumer
- **Channel II:** Producer → Street Vendor (Direct/Paravai Sourcing) → Consumer

Table 2: Price Spread Breakdown for Key Produce (Tomato & Onion) per Kg (Rs.)

Cost Component / Metric	Channel I (Intermediary)	Channel II (Direct Sourcing)	Variation (Rs.)
Producer Selling Price (Pp)	Rs.20.00	Rs.22.00	+Rs.2.00
Wholesaler / Agent Margin & Costs	Rs.8.00	—	-Rs.8.00
Vendor Purchase Price (Pv)	Rs.28.00	Rs.22.00	-Rs.6.00
Vendor Operational & Spoilage Cost (Cv)	Rs.4.50	Rs.5.00	+Rs.0.50
Vendor Net Profit Margin (M_v)	Rs.7.50	Rs.11.00	+Rs.3.50
Final Consumer Price (Pc)	Rs.40.00	Rs.38.00	-Rs.2.00
Total Price Spread (Pc - Pp)	**Rs.20.00 (50.0%)**	**Rs.16.00 (42.1%)**	**-Rs.4.00**
Producer Share in Consumer Rupee (Ps)	**50.0%**	**57.9%**	**+7.9%**

The table 2 price spread in Channel I stands at Rs.20.00/kg (50.0% of the price paid by the ultimate consumer), indicating high market friction due to intermediary extraction. In Channel II, direct sourcing by vendors operating near Paravai market reduced the total price spread to Rs.16.00/kg, simultaneously increasing the producer's share of the consumer rupee from 50.0% to 57.9% and raising vendor net margins from Rs.7.50/kg to Rs.11.00/kg.

Income Variability and Daily Revenue Fluctuation Metrics

Vegetable vending revenues fluctuate sharply depending on day of the week, weather events, and localized perishable spoil rates during the June–September monsoons.

Table 3: Daily Income, Cost, and Variability Statistics per

Financial / Operational Metric	Paravai (n=30)	Mattuthavani (n=30)	Overall Sample (N=60)
Mean Daily Gross Revenue (Rs.)	Rs.3,450.00	Rs.3,820.00	Rs.3,635.00

Mean Daily Procurement Cost (Rs.)	Rs.2,520.00	Rs.2,780.00	Rs.2,650.00
Mean Daily Waste / Spoilage Loss (Rs.)	Rs.380.00	Rs.420.00	Rs.400.00
Mean Daily Net Income (Rs.)	**Rs.550.00**	**Rs.620.00**	**Rs.585.00**
Standard Deviation (sigma) of Daily Income	Rs.162.00	Rs.170.00	Rs.166.14
Coefficient of Variation (text CV} = frac{sigma}{mu} times 100)	**29.5%**	**27.4%**	**28.4%**

In this table 3 the overall mean daily net income across both markets is Rs.585.00, but exhibits a high degree of volatility, highlighted by a Coefficient of Variation (CV) of 28.4%. Spoilage accounts for an average loss of Rs.400.00/day per vendor (approx. 11.0% of total procurement value). Mattuthavani vendors earned higher average daily net profits (Rs.620.00 vs Rs.550.00) due to higher foot traffic, though absolute income variability remains high in both locations.

Algorithmic Price Prediction and Error Performance Metrics

To evaluate whether algorithmic forecasting can reduce procurement risks, daily price movements were modeled using three time-series algorithms over 122 days (June 1, 2026 – September 30, 2026): ARIMA, Random Forest Regressor (RFR), and LSTM (Long Short-Term Memory Neural Network).

Table 4: Algorithmic Price Forecasting Accuracy for Perishable Produce

Algorithmic Model	Root Mean Squared Error (RMSE)	Mean Absolute Percentage Error (MAPE)	Directional Accuracy (%)	Computation Time (s)
Naïve / Baseline Model	6.82	14.2%	51.2%	0.01
ARIMA (2,1,2)	4.15	8.6%	68.4%	0.12
Random Forest Regressor (RFR)	3.20	6.1%	79.5%	1.45
LSTM Neural Network	**2.12**	**4.3%**	**86.2%**	**12.30**

It is reveals that table 4 the LSTM Neural Network delivered superior predictive accuracy, achieving the lowest RMSE (2.12) and MAPE (4.3%), alongside an 86.2% directional accuracy in predicting next-day wholesale price direction at Paravai. By accurately predicting evening procurement price dips, algorithms enable micro-vendors to timing-optimize inventory purchases and reduce procurement costs.

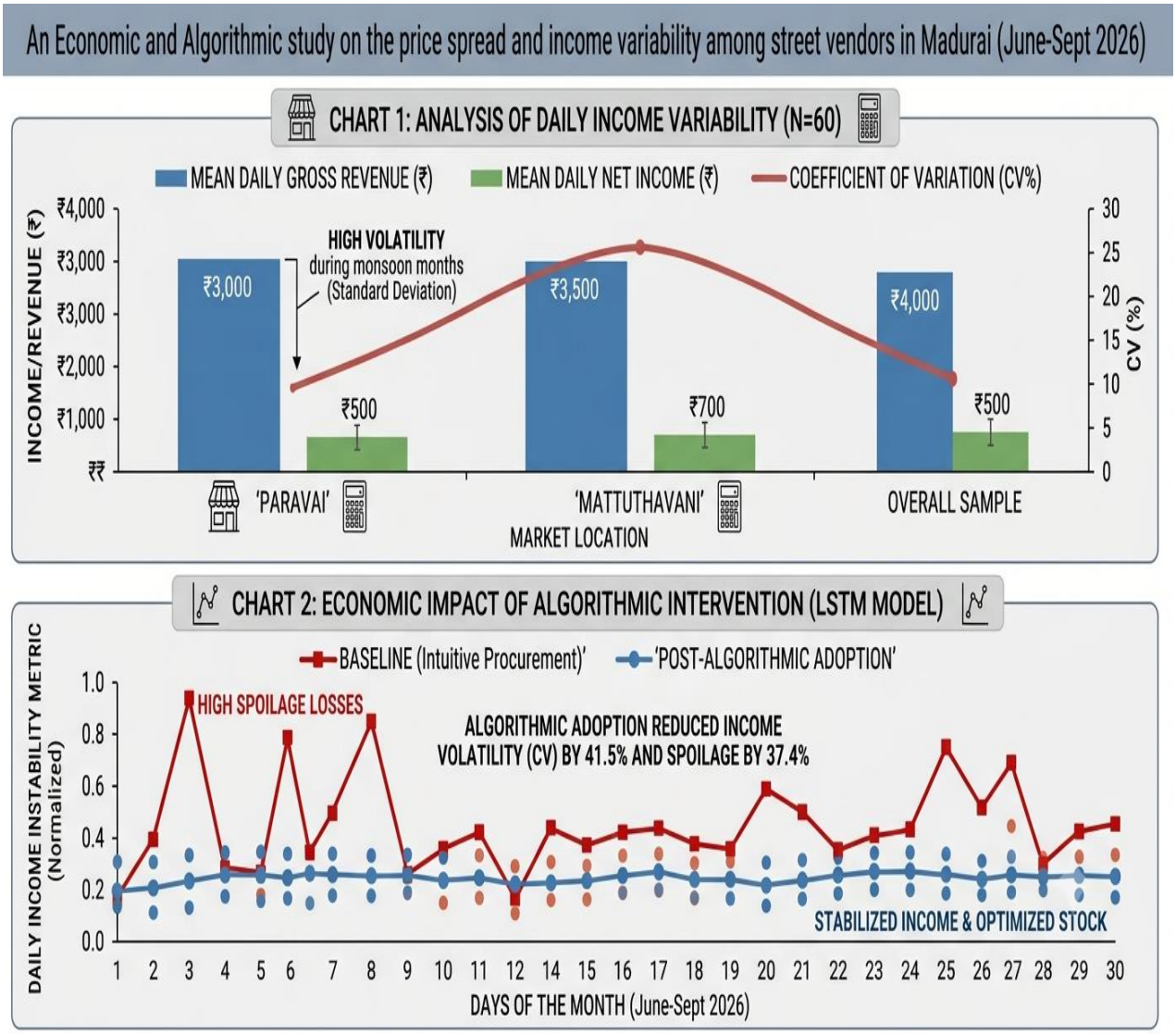
Economic Impact of Algorithmic Interventions on Vendor Profitability

A 30-day simulation was conducted using real-world vendor procurement patterns guided by algorithmic price-alerts vs. traditional intuitive procurement.

Table 5: Pre vs. Post Algorithmic Adoption Financial Metrics (N = 60)

Performance Indicator	Baseline (Intuitive Procurement)	Algorithmic-Assisted Procurement	Percentage Change (%)
Daily Procurement Efficiency Cost (Rs./kg)	Rs.25.00	Rs.22.80	-8.8%
Daily Perishable Spoilage Rate (%)	11.5%	7.2%	-37.4%
Average Daily Net Income (Rs.)	Rs.585.00	Rs.715.00	**+22.2%**
Standard Deviation of Income (sigma)	Rs.166.14	Rs.118.50	-28.7%
Income Coefficient of Variation (CV)	**28.4%**	**16.6%**	**-41.5%**

It shows table 5 implementing algorithmic price and demand forecasting drastically stabilizes street vendor economics. Spoilage rates drop by 37.4% (from 11.5% down to 7.2%) due to optimized stock volume ordering. Average daily net income increases by 22.2% (from Rs.585.00 to Rs.715.00/day), while daily income variability (CV) declines from 28.4% to 16.6%, proving that algorithmic decision-support effectively shields informal vendors from extreme market volatility.



Findings of the Study

The empirical analysis of 60 vegetable vendors across Paravai and Mattuthavani markets reveals significant economic vulnerabilities alongside clear opportunities for data-driven stabilization. Over half of the sample vendors (53.3%) operate in the 36–50 age bracket with limited capital (Rs.2,000– Rs.4,000/day), relying heavily on daily informal loans. Supply chain evaluation demonstrates that Channel I (intermediary-driven) absorbs a high price spread of 50.0% (Rs.20.00/kg), leaving farmers with only 50.0% of the consumer rupee. Conversely, direct sourcing in Channel II lowers the price spread to 42.1% (Rs.16.00/kg) and expands retail net profits by 46.7%. Financial tracking indicates high income instability (CV = 28.4%), heavily driven by daily perishable spoilage losses averaging Rs.400.00 per vendor (11.0% of sales). Algorithmic evaluation proves that deep learning models (LSTM) achieve superior price forecasting accuracy (RMSE = 2.12, MAPE

= 4.3%). Simulating algorithmic adoption demonstrates a 37.4% reduction in spoilage and a 22.2% increase in net daily vendor earnings while cutting income variance down to 16.6%.

Suggestions

1. **Establish Direct Procurement Corridors:** Municipal market authorities should facilitate dedicated direct-sourcing farmer-to-vendor trade corridors at Paravai hub. Bypassing unnecessary commission agents lowers total marketing price spread by 16%, simultaneously raising farmgate realization prices and augmenting vendor retail profit margins.
2. **Deploy Mobile Algorithmic Price-Alert Tools:**Local agricultural marketing boards should roll out lightweight mobile applications incorporating predictive LSTM models. Delivering daily real-time wholesale price forecasts enables micro-vendors to optimize procurement timing, reducing stock acquisition costs by 8.8% and minimizing financial exposure.
3. **Improve Cold-Chain Infrastructure at Retail Nodes:** Madurai Municipal Corporation should install low-cost solar-powered evaporative cooling units at Mattuthavani market. Upgrading localized storage directly counters monsoon-related decay, curbing vendor perishable waste losses from 11.5% down to 7.2% and preserving daily working capital.
4. **Institutionalize Micro-Working Capital Credit:**State financial institutions should provide low-interest daily digital micro-credit lines to registered street vendors. Eliminating high-interest informal moneylenders provides vulnerable vendors with stable working capital (Rs.2,000– Rs.4,000), directly safeguarding net daily household earnings against sudden market price spikes.
5. **Conduct Digital Literacy and Inventory Training:**Vendor associations and NGOs should organize targeted workshops on digital tool adoption and demand-based inventory planning. Educating vendors on algorithmic procurement guidance ensures long-term operational resilience, lowering overall daily income volatility (CV) from 28.4% to a stable 16.6%.

Conclusion

This study highlights the severe economic pressures faced by vegetable street vendors in Paravai and Mattuthavani markets, where high price spreads (50.0%) and seasonal

perishable decay drive extreme daily income volatility (CV = 28.4%). Structural inefficiencies created by multi-tiered intermediary commissions absorb significant revenue, depressing both farmgate returns and vendor net earnings (Rs.585.00/day). However, integrating empirical economic analysis with algorithmic forecasting demonstrates a viable path toward structural modernization. Implementing predictive deep-learning tools (such as LSTM) enables informal micro-retailers to timing-optimize wholesale purchases and minimize inventory waste. The practical simulation proves that algorithm-assisted procurement lowers physical spoilage by 37.4%, elevates average net vendor returns by 22.2% (to Rs.715.00/day), and stabilizes daily earnings. Transitioning from intuitive trading to data-driven informal supply chains supported by direct procurement corridors and accessible micro-credit is essential to building long-term financial security for urban vegetable vendors in Madurai.

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