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Identify Back-Loading Risks through Spatial Data Analysis

Ankrity Das[1]

Abstract

Cement industry in India follows a multiple basing point model of geographic pricing in trade channel. Rail heads emerge as primary basing points for calculation of delivered prices in a market. For local players supplying by road, positive correlation between price and freight gets disrupted creating arbitrage opportunities for dealers and transporters, which are popularly called "back-loading" risks. As visual detection of such anomalies by simple geo-mapping is difficult given the scale and dispersion of price data, an alternate spatial analysis approach using Moran's I is suggested in this paper. It is shown that plot of local Moran's I of all destinations against average values of their distance weighted neighborhood helps detect points which lie in neighborhoods of opposite polarity and thereby candidates for back-loading. Suitable measures like GPS tracking and price corrections may be employed at such points to arrest leakage in realizations.

Keywords: Backloading, Cement, Morans, Pricing, Spatial.

1. Introduction

In India, cement is sold through two types of distribution channels–physical trade (retail) and institutional (large buyers). In a typical two tier trade channel, cement is sold by the manufacturer to its 'dealers who sell to their retailers from whom actual consumers are supplied. The channel activities of order collection, fulfilment monitoring, promotional activities, market intelligence and pricing are done by company's sales officers. Orders are collected from dealers on a regular basis by the sales team and fulfilled from factories or warehouses at delivered prices determined by location of the delivery point.

This geographic pricing is influenced by the structure of the cement industry

- Highly standardized product due to compulsory adherence to national quality norms and low levels of product innovation.
- Low value per weight ranging from INR 5 to 8 per kilogram of cement (Indian Cement Review, n.d.)
- Logistics costs account for high share (15% to 20%) of delivered cement price (Indian Bureau of Mines, 2015, p. 17)
- Production units are specialized, long lived and require large capital investments (Indian Cement Review, n.d.)
- Seasonal nature of demand and limited product life necessitates a made to order supply chain and less than capacity output

1. Senior Manager, Corp. Supply Chain, Dalmia Bharat Cements Ltd.

- Oligopolistic market structure with top 6 companies accounting for 50% of total production in 2015-16. (Indian Bureau of Mines, 2015, p. 16)
- Production units are clustered in remote areas near raw material sources of limestone, fly ash or blast furnace slag while geographical dispersion of markets are influenced by demographic factors of population and average income levels.
- Cost economies of rail over road movement for large distances greater than 300 km. (National Council of Applied Economic Research, 2016)

These characteristics have led to emergence of a multiple basing point pricing system (Landon, 1950) where in distant units supply compete with local players in their home markets by supplying through rail.

A rail head with adequate goods handling infrastructure often emerges as the largest source of supply in the market on aggregation of supplies from all players and becomes the primary basing point for calculation of delivered prices. A minimum landed price is determined at the rail head and delivered prices are calculated to all destinations in the market by adding the road freight to the destination.

Local players benchmark against these prices while supplying at a lower cost by road and benefiting from "phantom" freight built into the delivered prices(Philips, 1976). However, the business logic that delivered prices should increase in the increasing order of freight gets disrupted for local players due to different source locations thereby creating potential for arbitrage by dealers and transporters popularly called "back-loading" risk. For a pair of destinations whose relationship of prices are opposite of their freights, dealers may collude with transporters and place order at low price/ high freight destination and ensure delivery at high price/ low freight destinations. The dealers would benefit from buying at low price while transporters would benefit by charging high freight as per the destination mentioned in sales order.

Detection of such spatial anomalies through basic geo-visualization of prices is a tedious process due to large size and dispersion of delivery points. Objective of this paper is to suggest an exploratory spatial data analysis technique to quickly uncover destinations vulnerable to back-loading for a local manufacturer.

2. Methodology

The study focuses on Portland Slag Cement (PSC) market in the state of West Bengal in India for a prominent cement manufacturer. The delivered prices of cement and HCV (Heavy Commercial Vehicles) freights from designated supply point for 276 destinations have been considered in the study.

While any two destinations may theoretically become candidates for back-loading, risk tends to higher for destinations within zones of influence for a dealer. As dealers are typically clustered by administrative districts and districts typically are approximately 30 to 40 km end to end, it is reasonable to consider circle of influence to have50 km radius.

Unusual high or low delivered prices at a destination relative to its neighbors create a risk for back-loading. Local Moran's I as Local Indicator of Spatial Association (Anselin, 1995) is appropriate to detect this risk as it indicates nature of correlation of a point with its neighbors with positive correlations indicating similar values and negative correlations indicating dissimilar values (Anselin, 1996). Neighbors within 50 km radius of a destination have been considered for analysis through distance weights. GeoDa v1.8.12 software has been used for computations and map plotting in this study.

3. Results

Global Moran's I is 0.0771indicating lack of any spatial association among delivered prices in the 276 destinations which can be attributed to the existence of multiple local markets with their own basing points.

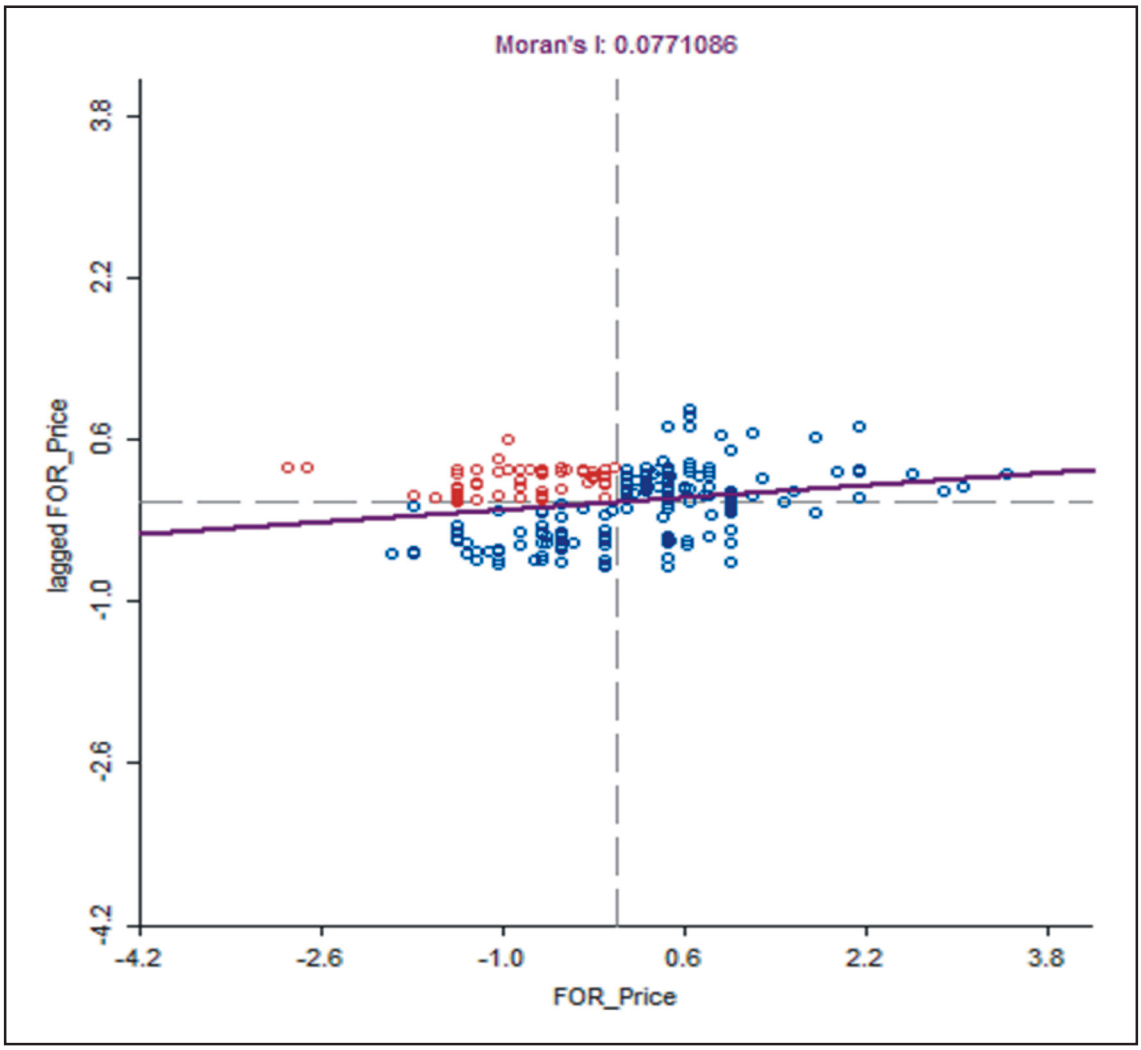

Figure 1: Moran's I Scatterplot, FOR Prices for PSC in West Bengal

In Moran Scatterplot, the upper left quadrant of "Low-High" (destinations whose prices are distinctly lower compared to the neighborhood) is of particular interest as orders placed for these destinations run the risk of getting delivered in the higher price neighborhood enabling the dealer to augment his margins.

The lower right quadrant of "High-Low" (destinations whose prices are distinctly higher compared to the neighborhood) run the risk of appearing as under-performing areas in terms of sales while creating arbitrage opportunities for transporters.

Figure 2: Plot of Destinations Categorized by Local Moran's I at Significance of 99.90%

In accordance with Tobler's First Law of Geography that "Everything is related to everything else, but near things are more related than distant things", Clusters 'A' and 'B' are chosen for deep dive into neighborhoods of "Low-High" and "High-Low" destinations respectively.

Destination	Category	Price (Rs. per bag)	Freight (Rs. per bag)	Latitude (degree)	Longitude (degree)
D001	Low-High	345	53	24.10	88.27
D002	Low-High	345	53	24.06	88.34
D003	Low-High	346	53	24.17	88.28
D028	Low-High	354	53	23.92	88.46
D153	High-High	364	47	23.78	88.29
D150	Insignificant	364	53	23.85	88.20
D151	Insignificant	364	53	24.12	88.54
D152	Insignificant	364	53	24.10	88.28
D182	High-High	365	49	23.93	88.59

Figure 3: Delivered Price and Freight Data for Cluster 'A'

In cluster 'A', four low price destinations (D001, D002, D003 and D028) are located close to five higher price neighbors with price gap ranging from Rs.10 to Rs.20 per bag. The freights for low price destinations are equal or higher compared to high price neighbors creating arbitrage opportunity for transporter up to Rs.6 per bag.

Destination	Category	FOR_Price (Rs. per bag)	Freight (Rs. per bag)	Latitude (degree)	Longitude (degree)
D198	High-Low	365	16	22.16	87.11
D197	High-Low	365	22	22.16	87.11
D193	High-Low	365	17	22.13	87.23
D132	Low-Low	362	19	22.44	86.99
D131	Insignificant	362	25	22.52	86.85
D099	Insignificant	360	18	22.51	87.43
D093	Low-Low	360	13	22.08	87.35
D092	Insignificant	360	18	22.38	87.44
D091	Insignificant	360	14	22.02	87.43

Figure 4: Delivered Price and Freight Data for Cluster 'B'

Similarly, in cluster 'B', dealers may book orders for other destinations and seek delivery at three "High-Low" destinations (D198, D197 and D193) thereby generating arbitrage of Rs.5 per bag for themselves and up to Rs.6 per bag for transporter.

4. Conclusions

Spatial correlation analysis of delivered price data using Moran's Scatterplot is useful in detection of geographical areas vulnerable to back-loading. Logistics measures of installing GPS based tracking systems on all vehicles delivering to "Low-High" destinations and geo-fencing of "High-Low" destinations to detect unauthorized deliveries can arrest this leakage. A more strategic solution can be achieved by right pricing of "Low-High" and "High-Low" neighborhoods thereby reducing the attractiveness of the available arbitrage. If margin leakage is happening through back-loading, it may make more sense to correct prices so that "Low-High" destinations which tend to develop into invisible white spaces in terms of product availability start receiving material. Study can be developed further through bivariate spatial correlation between price and freight to detect destinations where both parameters not only have negative correlations but also opposite polarities i.e. Price "Low-High"/ Freight "High-Low" or Price "High-Low"/ Freight "Low-High" compared to their neighbors for more accurate pinpointing of vulnerable areas.

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