The Last Mile Gap: How Retail Unavailability Creates Phantom Demand and Amplifies the Bullwhip Effect

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Abstract

Last mile logistics failures in remote and semi-urban markets create a unique paradox. Products that are neither rare nor premium become functionally unavailable due to distribution gaps, triggering a supply deficiency. This paper examines how such retail unavailability triggers a phantom demand phenomenon upstream in the supply chain. When a consumer visits multiple retail outlets in search of a routinely available product, each retailer independently registers a lost sale and places compensatory orders with their distributor. The distributor, interpreting these orders as genuine demand signals, inflates upstream forecasts accordingly. The result is a demand amplification that bears no relationship to actual consumer need. This is a supply-side trigger of the bullwhip effect distinct from the four operational causes identified by Lee, Padmanabhan and Whang (1997). This paper conceptualizes this mechanism as Last Mile Demand Distortion (LMDD) and proposes a framework for understanding how infrastructure-driven stockouts may create false demand signals in supply chains.

Keywords: Last mile logistics, bullwhip effect, phantom demand, demand signal distortion, remote markets, supply chain management

1. Introduction

Supply chain management literature has long recognized the bullwhip effect as one of the most persistent and costly inefficiencies in demand-driven systems. First observed and documented by Forrester (1958) at MIT and later formalized by Lee, Padmanabhan and Whang (Lee *et al.*, 1997), the bullwhip effect describes the amplification of demand signal variability as orders

travel upstream through a supply chain. A small fluctuation at the retail level triggers disproportionately larger fluctuations at the distributor, manufacturer and raw material supplier levels.

The four canonical causes identified by Lee *et al*. (1997): demand signal processing, order batching, price fluctuations and rationing or shortage gaming, are operational in nature. They assume that retail demand exists and is either being wrongly processed, batched or gamed. What the literature has not sufficiently examined is a scenario where retail demand cannot be expressed accurately at all, not because the consumer does not want the product, but because the product is physically unavailable at the point of purchase. Yang *et al.* (2021), in a systematic literature review of 53 sources, summarized behavioural factors among supply chain actors like target ratcheting of incentive misalignment as causes of bullwhip effect.

Last mile logistics refers to the final segment of the supply chain connecting a distribution hub to the consumer's preferred destination. It is the point at the critical interface where product availability meets customer service (Chatterjee & Paul, 2023; Suguna et al., 2022). This stage is often described as the most expensive, inefficient, and complex part of the supply chain (Olsson et al., 2019). While last-mile research has recently focused on digital e-commerce customer satisfaction (Vakulenko et al., 2019), the physical availability constraints in brick-and-mortar retail environments within developing markets remain critically understudied. Efficient last-mile connectivity and delivery logistics are no longer just operational necessities but strategic differentiators in a market shifting from consumer accessibility to distribution capabilities (Rodrigue, 2022; Sułkowski et al., 2022).

This paper draws attention to a specific and underexplored context: remote and semi-urban markets in developing economies where last mile logistics infrastructure is weaker. In such markets, towns and districts in Northeast India for example, products that are common in metropolitan retail environments are frequently absent from local shelves. This absence is not the result of low consumer demand. It is the result of distribution inadequacy.

Retail stockouts, defined as the temporary unavailability of a normally sold product at the time of purchase, remain a persistent challenge across both traditional and digital commerce landscapes (Nagare & Dutta, 2014; Vasconcellos & Sampaio, 2009). Research has indicated that stockout rates across retail industry has remained more or less similar. The rates reported

from 1963 (Peckham, 1963) to 2002 (Gruen *et al.*, 2002) hover around 8%. Gruen *et al.* (2003) identified that 28% of stockouts were due to poor inventory planning.

When faced with a stockout, consumers exhibit a range of behavioral responses often categorized by the acronym SDL: Substitute, Delay, or Leave (Nagare & Dutta, 2014; Sampaio & Sampaio, 2015). Research suggests that approximately 45% of consumers will substitute their desired item with a different brand or size, while 31% will leave the store to shop elsewhere, and 14% will delay or cancel their purchase entirely (Gruen & Corsten, 2003; Nagare & Dutta, 2014). These reactions are frequently driven by "psychological reactance," a negative motivational state that occurs when a consumer's freedom to choose a preferred option is restricted. The severity of the response is typically proportional to the consumer's "personal commitment" to the out-of-stock item, which increases if the product was highly preferred or included in the consumer's active consideration set (Fitzsimons, 2000).

The consequences of stockouts transcend the immediate loss of a sale, encompassing long-term costs such as customer dissatisfaction, negative word-of-mouth, and the permanent loss of store or brand loyalty (Fitzsimons, 2000; Nagare & Dutta, 2014). Strategic management of the last mile and product availability is therefore essential, as stockouts distort demand data and lead to inaccurate forecasting, further exacerbating the Bullwhip Effect and increasing operational costs across the supply chain (Adusei & Awunyo-Vitor, 2014; Saoud et al., 2025). Understanding the interplay between inventory policies, last-mile efficiency, and consumer behavioral responses is vital for retailers seeking to balance product assortment with the necessity of maintaining high service levels (Fitzsimons, 2000; Olsson et al., 2019)

The consequences of this absence, however, travel upstream in ways that the supply chain does not anticipate. This paper proposes that consumer search behaviour triggered by retail unavailability creates a pattern of compensatory retail ordering that mimics genuine demand spikes, a phenomenon the author terms Last Mile Demand Distortion (LMDD). The paper argues that LMDD constitutes a supply-side trigger of the bullwhip effect that is conceptually distinct from the four causes identified in foundational literature and warrants formal investigation.

2. The Last Mile Problem in Remote Markets

Last mile logistics refers to the final leg of the supply chain, the movement of goods from a distribution hub to the end consumer or retail point. It is widely recognized as the most

expensive, time-consuming and operationally complex segment of the logistics network (Mangiaracina *et al*., 2015). In urban markets, last mile challenges manifest primarily as traffic congestion, delivery density constraints and rising consumer expectations. In remote and semi-urban markets, the problem is more fundamental: the infrastructure to sustain consistent product availability does not exist.

In Tier II and Tier III markets across India, last mile delivery faces structural barriers including poor road connectivity, absence of cold chain infrastructure, low delivery density and dependence on informal distribution networks with limited tracking capability. The result is a pattern of irregular replenishment cycles where retail shelves cycle between overstocking immediately after delivery and stockouts in the periods between deliveries.

Critically, the products affected are not luxury or specialty goods. They are routinely consumed packaged goods, like staple foods, personal care products or household consumables, that consumers expect to find in any general store. When these products are unavailable, consumer behaviour does not simply register a missed purchase. It generates a search pattern with significant downstream consequences for demand signal accuracy. As cited in the sections above, research indicates that when a desired item is unavailable, approximately 32% of consumers purchase a different brand, while about 13% choose to delay their purchase, and 14% leave to find the item at another store (Fitzsimons, 2000).

3. The Mechanism: Consumer Search Behaviour and Phantom Demand

Consider the following scenario, drawn from the retail geography of a remote town in Northeast India. A consumer requires a single unit of a standard packaged food product. The first retail store visited does not have the product in stock. Nor does the second. The consumer visits a third, fourth and fifth store before eventually locating the product at the eleventh outlet.

The consumer's demand was singular, one unit of one product. But the supply chain does not observe this. What the supply chain observes is the behaviour of ten retailers who experienced a customer request for a product they did not have. Out of the 27% of the customers that leave or delay their purchase (Fitzsimons, 2000), research by Ponte *et al.* (2017) indicates that sellers account for the missed sales by placing backlog orders. Each of those ten retailers, independently applying rational inventory logic, concludes that demand exists for that product in their locality. Each retailer places an order with their distributor. The distributor receives ten orders for a product that one consumer wanted once. This scenario is unique because in a supply

chain, the retailer is the only node that observes actual customer demand. So the information flow upwards that starts at the seller/retailer is the organic input data for the entirety of the supply chain.

The distributor, operating without visibility into the consumer's actual behaviour, interprets these ten orders as ten independent demand signals. Upstream forecasting adjusts accordingly. Production targets increase. Distribution resources are reallocated. The supply chain mobilizes to meet demand that, in reality, was a single purchase multiplied tenfold by infrastructure failure.

When supply is eventually restored and the product becomes available across multiple outlets simultaneously, consumer demand does not absorb the inflated stock. The anticipated demand spike does not materialize. Inventory accumulates at the retail and distributor level. The supply chain then contracts sharply — cancelling orders, reducing production — creating a trough that is as artificial as the preceding spike. This oscillation is structurally identical to the bullwhip effect as described by Lee *et al*. (1997), but its origin is not in demand variability or ordering behaviour. Its origin is in the failure of customer service due to physical failure of last mile logistics.

4. Conceptual Framework: Last Mile Demand Distortion

This paper proposes a conceptual framework, Last Mile Demand Distortion (LMDD), to conceptualize the mechanism described above. The framework can be understood as an extension to already established Bullwhip Effect (BWE) literature. The framework identifies four sequential stages:

Stage 1: ***Last Mile Failure***: Irregular or insufficient last mile logistics result in retail stockouts at multiple outlets within a geographic area.

Stage 2: ***Consumer Search Behaviour***: Consumers seeking the unavailable product visit multiple retail outlets. Each unsuccessful visit constitutes a demand signal that the retailer registers but cannot fulfil. This signal is then recorded and accounted as backlog order.

Stage 3: ***Compensatory Retail Ordering***: Each retailer independently places backlog orders with their distributor, interpreting the consumer visit as evidence of local demand. This is similar in nature to one of the operational causes of Bullwhip Effect proposed by Lee *et al.*

(1997), demand signal processing. The aggregate of these orders constitutes phantom demand, demand signals that do not reflect actual consumer purchasing power or intent.

Stage 4: ***Upstream Amplification***: The distributor and upstream supply chain actors receive inflated order signals, adjust forecasts and production accordingly and the bullwhip effect is initiated from the supply side rather than the demand side.

The mechanism operates due to the lack of coordination inherent to multi-echelon supply networks as studied by Croson *et al.*, (2014) and the demand signal processing operational cause identified by Lee *et al*. (1997). The mechanism is visualized in the Figure 1 below: -

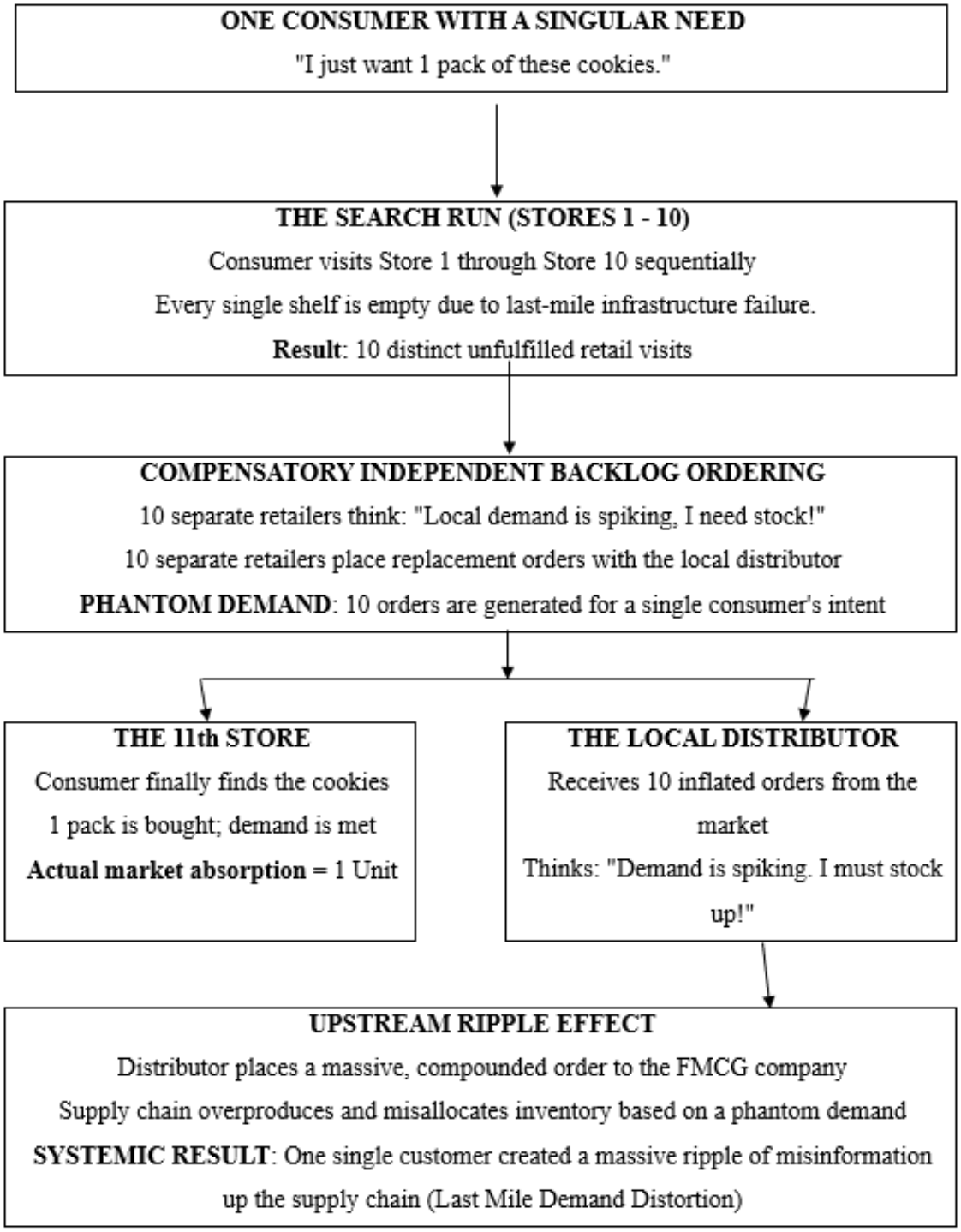

Figure 1: The Last Mile Demand Distortion (LMDD) Framework

LMDD is distinguished from existing bullwhip causes in a critical respect. The four causes identified by Lee *et al*. (1997) all originate in how demand signals are processed post generation, batched or gets gamed by supply chain actors in efforts to reduce personal costs. The assumption is that the actual consumer demand exists and is being distorted during

transmission. LMDD, by contrast, originates before any legitimate demand signal is processed. The distortion is not in the transmission of demand, it is in the creation of phantom demand where none, or significantly less, actually existed.

This distinction has theoretical significance. It suggests that the bullwhip effect can be triggered not only by behavioural responses to demand signals, but by the structural failure of the distribution network to translate actual demand into fulfilled transactions. In remote markets with chronic last mile failures, LMDD may operate as a persistent background distortion, continuously introducing noise into upstream demand signals regardless of actual consumption patterns.

5. Implications

5.1 For Supply Chain Managers

Companies operating in remote and semi-urban markets that rely on primary sales data, the volume of goods shipped from company to distributor, as a proxy for consumer demand are particularly vulnerable to LMDD. Primary sales in such markets may reflect distributor ordering behaviour driven by phantom retail demand rather than actual end-consumer purchases (Secondary sales). Demand planners may incorporate secondary sales data, actual sales from retailer to consumer, as the primary demand signal in markets with documented last mile irregularities.

5.2 For Last Mile Logistics Providers

The cost of last mile logistics failures is typically calculated in terms of delivery costs, customer dissatisfaction and lost sales at the retail level. LMDD suggests an additional, upstream cost: the distortion of demand signals that leads to misallocated production resources, excess inventory and artificial demand volatility across the supply chain. Investment in last mile reliability in remote markets may therefore yield supply chain efficiency gains that significantly exceed the direct cost of the logistics improvement.

5.3 For Researchers

LMDD opens a research agenda at the intersection of last mile logistics and demand signal distortion. Empirical validation of the framework would require measurement of the primary-secondary sales gap in markets with documented last mile irregularities, correlated with the

frequency and duration of retail stockout events. Agent-based modelling approaches could simulate the LMDD mechanism to identify threshold conditions under which the distortion becomes material to upstream forecasting.

6. Conclusion

This paper has proposed Last Mile Demand Distortion as a conceptual mechanism by which the physical failure of last mile logistics in remote markets generates phantom demand signals that amplify the bullwhip effect upstream. Unlike the four operational causes identified by Lee *et al*. (1997), LMDD originates on the supply side, in distribution infrastructure failure, rather than in the behavioural processing of demand signals by supply chain actors.

The mechanism is theoretically grounded in consumer search behaviour literature and structurally consistent with existing bullwhip effect theory. It is particularly relevant to the supply chain contexts of developing economies where last mile infrastructure gaps are systemic rather than exceptional.

Future empirical work should test the LMDD framework using primary and secondary sales data from FMCG distribution networks operating in remote geographies, with stockout frequency as the independent variable and primary-secondary sales gap as the proxy for demand signal distortion. If validated, LMDD would constitute a sixth cause of the bullwhip effect, independent of the four operational causes identified by Lee *et al*. (1997) and behavioural causes as a whole summarized by Yang *et al.* (2021), one whose remedy lies not in information technology or forecasting improvement, but in the unglamorous and often overlooked work of improving the reliability of last mile logistics infrastructure.

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