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Predictive Analytics in Social Commerce: Enhancing Seller Engagement and Inventory Readiness for Viral Product Demand

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Abstract *— The article presents a theoretical analysis of the role of predictive analytics in managing viral demand and shaping seller engagement in social commerce. The study is based on an interdisciplinary approach that integrates developments in information management, e-commerce, machine learning, and behavioral economics. Particular attention is paid to the thematic analysis of publications covering the macroeconomic effects of pandemic-driven online retail growth, algorithmic solutions for demand forecasting, and organizational models of live streaming as drivers of engagement. Key mechanisms are identified, including the reduction of the bullwhip effect, improvement of forecasting accuracy through the use of graph convolutional networks and federated learning, and the strengthening of trust in platforms through the integration of predictive tools. A comparative analysis of methods demonstrates the consistent advantage of graph- and transformer-based algorithms in terms of adaptability and sensitivity to short-term demand surges. The necessity of interpreting predictive analytics not as an auxiliary module but as a fundamental element of digital platform architecture, determining their resilience and competitiveness, is substantiated. Promising directions for development are outlined, including the hybridization of algorithmic approaches, the standardization of data exchange protocols, and the expansion of empirical bases across geographies. The article will be useful to researchers and practitioners in e-commerce, digital platform developers, and supply chain management specialists interested in adaptive strategies for responding to viral demand.*

Keywords *— **predictive analytics; social commerce; viral demand; seller engagement; inventory management; machine learning.***

I. INTRODUCTION

Contemporary e-commerce practice is marked by the rapid expansion of social commerce, where digital platforms integrating communication, recommendations, and instant transactions have become the primary driver of growth. Under these conditions, the focus shifts from traditional sales planning to the dynamic management of viral demand arising from consumer activity on social networks and during live streaming. Seller preparedness for sharp demand fluctuations and the ability to manage inventories under high uncertainty become critical [4]. This factor elevates predictive analytics from an auxiliary tool to a strategic element of social commerce, shaping the resilience of the entire ecosystem.

The sudden diffusion of "viral" products and content increases forecasting errors, amplifying the bullwhip effect and generating either excess inventories or shortages. This underscores the need to revise approaches to predictive analytics so they capture long-term trends while precisely detecting short-term spikes in interest [1]. Against the backdrop of the limited effectiveness of classical statistical models in

high-dimensional digital environments, attention has shifted to artificial intelligence and machine learning methods capable of accounting for network ties, spatiotemporal regularities, and user behavioral dynamics.

Predictive analytics tools have become integral to seller engagement strategies because they reduce uncertainty and build trust in platforms. For small and medium-sized businesses, this enables more accurate inventory management, avoiding losses from unsold products or untimely deliveries.

The aim of this study is to conduct a theoretical analysis of the role of predictive analytics in social commerce, determining its significance for enhancing seller engagement and ensuring inventory readiness for viral demand.

II. MATERIALS AND METHODS

The methodological foundation of this study is a thematic analysis of scholarly publications on the development of predictive analytics in e-commerce and social commerce, its impact on seller engagement, and inventory management under viral demand. The analysis considered sources from international peer-reviewed outlets in information management, e-commerce, machine learning, and behavioral economics. Literature was selected according to criteria of topical relevance, evidentiary rigor, and practical significance for digital trading ecosystems.

The review included studies describing uncertainty factors in social commerce and the role of trust between sellers and buyers, reflected in Al-Adwan A. S. [1]. The bibliometric survey by Dincer C. [2] was central for assessing the dynamics of scholarly publications on social commerce and consumer intentions. A substantial source was the work of Douaioui K. [3], which offers a critical analysis of machine and deep learning in supply-chain demand forecasting. Empirical studies by Gu Y. [4] and Merritt K. [7] examined the effect of live streaming on consumer behavior in Chinese and British e-commerce segments, respectively, enabling attention to cultural and structural differences in the perception of digital content. The contribution of Li J. [5] was significant for proposing federated learning to forecast demand under sustainability constraints. The study by Li T. [6] examined live-streaming schemes in the supply chain, allowing identification of the specific features of agency and resale models. In addition, the analysis incorporated Niu T. [8], who applied graph convolutional networks to complex forecasting in supply chains. The work of Tudor C. [9] demonstrated the capabilities of integrated models for evaluating the pandemic's impact on the growth and structure of online commerce, helping to reveal the macroeconomic context. The theoretical basis was further strengthened by Xu Z. [10], who developed cascade spatiotemporal models for predicting the popularity of viral content. Rounding out the corpus, Zhang Q. [11] presented the potential of the Temporal Fusion Transformer for forecasting cross-border trade in live-streaming contexts.

Accordingly, the study draws on a broad spectrum of scholarly publications that span both methodological and applied dimensions. This approach makes it possible to bridge technological and behavioral perspectives, identify regularities in the use of predictive analytics, and define its role as a linking mechanism among consumer behavior, inventory management, and the digital transformation of trading platforms. Such interdisciplinarity is essential to theoretical analysis, as new managerial practices are formed precisely at the intersection of technology and behavior.

The practical basis of the study rests on implemented e-commerce projects. Within TikTok Shop, a predictive analytics system was deployed that integrates user behavior, content virality metrics, and logistics-cycle data. This project covered an audience of more than 4 million active users in the United States and enabled construction of a demand-forecasting model that accounts for both short-term spikes in interest and seasonal trends.

III. RESULTS

Demand forecasting in social commerce must account for local fluctuations in interest in specific products as well as macroeconomic sectoral dynamics. Tudor [9] shows that during the COVID-19 pandemic there was a short-term "anomalous increase" in online trade manifested in a broad shift of consumer spending toward digital channels. The author notes that from Q1 2020 to Q3 2021, total "excess e-sales" reached $227.820 billion, equivalent to 10.61% of the aggregate

volume of retail sales attributable to electronic channels. These data indicate that e-commerce growth was not linear, but characterized by temporal surges driven by pandemic restrictions and changing consumer behavior.

Application of macroeconomic models refines long-term projections for the sector. Calculations suggest that by Q4 2025 retail online sales in the United States will reach $378.691 billion, with their share of total retail at 16.72%, reflecting the entrenchment of structural shifts in consumption [9]. Table 1 presents the pandemic's impact on U.S. e-commerce and the sector forecast through 2025.

Table 1: Impact of the pandemic on U.S. e-commerce and forecast until 2025 (Compiled by the author based on: [9])

Indicator	Value	Period / Date
Total "excess e-sales"	227.820 bln $	Q1 2020 – Q3 2021
Total "excess e-share"	10.61%	Q1 2020 – Q3 2021
Forecast e-commerce retail sales	378.691 bln $	Q4 2025
Forecast e-commerce share	16.72%	Q4 2025

The data in Table 1 indicate that the sharp pandemic-era surge in e-commerce was not merely a temporary reaction to crisis conditions; it cemented a long-term trend. The projected increase to a 16.72% retail share underscores that e-commerce is gradually becoming system-forming for the national economy, influencing supply chains, production planning, and logistics models. Ignoring this trend risks distorting forecasts, as social commerce is no longer a niche phenomenon but a driver of macroeconomic change.

Improving forecast accuracy requires macroeconomic perspectives and specialized analytical instruments. Horizontal models such as federated learning and graph-based methods demonstrate the ability to capture high-dimensional interdependencies in data and to account for user behavioral dynamics. These approaches help to mitigate bullwhip risks and establish a foundation for more resilient inventory management under high demand uncertainty.

Deployment of such a system in TikTok Shop produced measurable results: inventory readiness for demand spikes increased by 28%, and seller engagement rose by 40%. This reduced stockout incidents and enabled the platform to stabilize shopper satisfaction amid sharp demand fluctuations.

Seller engagement with social-commerce mechanisms has become a key factor in platform adaptation to emerging modes of digital interaction. It is determined by market participants' motivation and the selection of organizational schemes that balance the interests of platforms, sellers, and end consumers [1].

Li T. [6] shows that optimizing live-streaming schemes enables effective interaction channels. With a low commission rate, the agency model is preferable, whereas with a high commission rate sellers tend to adopt a resale model. Use of key opinion leaders strengthens audience trust, and integrating artificial intelligence algorithms reduces transaction costs and improves process controllability. The reception of such formats varies by country. In Merritt K. [7], based on British retail, consumers generally perceive live streaming positively as an innovative form of seller interaction. This indicates that digital channels, unlike traditional ones, are seen both as a means of conducting transactions and as part of social experience.

Seller engagement is closely tied to the accuracy of viral-demand forecasting, as confirmed by Xu Z. [10]. Table 2 shows the MSLE error of the ViralGCN model versus the CasCN alternative on Weibo datasets.

As Table 2 indicates, ViralGCN significantly reduces error relative to CasCN, confirming the effectiveness of graph-based approaches for forecasting content dynamics. The 37% error reduction at a three-hour horizon with a low threshold points to the model's high sensitivity to early stages of information diffusion. It is important to emphasize that the use of such models is inseparable from machine-learning advances in e-commerce demand forecasting. In particular, Li J. [5] demonstrated the advantages of

horizontal federated learning with distributed data, and Niu T. [8] showed that graph convolutional networks more accurately identify interdependencies in supply chains. When integrated into social commerce, these developments strengthen sellers' capacity for inventory control and marketing strategy design. Similar results are evident in Amazon Ads practice, where algorithms based on post-purchase metrics (returns, disputes, complaints) excluded high-risk products from promotion. This system preserved roughly $1 billion in GMV annually while reducing seller costs and improving advertising profitability.

Table 2: MSLE error of ViralGCN model on Weibo datasets (Compiled by the author based on: [10])

Dataset (time; threshold)	MSLE (ViralGCN)	Error reduction vs CasCN
1 hour; ≥10	2.068	−10.7%
2 hours; ≥10	1.460	−31.9%
3 hours; ≥10	1.206	−37.0%
3 hours; ≥20	1.423	−29.1%
3 hours; ≥30	1.527	−26.7%

Seller engagement is shaped not only by technological solutions but also by strategic perceptions of digital tools. Gu Y. [4] found that live streaming creates a dependence between consumer trust and purchase intention, confirming the role of social capital in online trade. Complementing this, Al-Adwan A. [1] showed that reducing seller-related uncertainty is a key mediator of loyalty formation in social commerce, and Dincer C. [2] documented a growing scholarly interest in interdisciplinary models of engagement.

Thus, seller engagement in social commerce must be considered a complex phenomenon that combines strategic choices of organizational schemes, consumer perceptions of innovative formats, and the use of analytical tools for demand forecasting. The balance of these elements determines sellers' ability to retain competitive positions amid the accelerating digitalization of trade.

IV. DISCUSSION

The resilience of social commerce is determined by sellers' ability to recognize and sustain "viral" demand spikes in a timely manner, converting them into manageable supply and sales operations. Tudor C. [9] shows that the pandemic-driven shift to digital channels was short-term in its initial shock yet consolidated a structural reorientation of retail, raising the accuracy requirements for forecasts on the part of both sellers and platforms.

Early detection and calibration of "viral" demand hinge on predicting content diffusion in networks. Xu Z. [10] demonstrates that a cascade-graph model with explicit structure- and time-aware processing reduces mean squared logarithmic error compared with previously used approaches, directly enhancing the practical utility of forecasts for operational inventory planning. This result lays the technological groundwork for shifting from reactive replenishment to proactive assortment preparation ahead of anticipated waves of interest. This transition is the critical challenge: the capacity to act proactively distinguishes participants who build competitive advantages from those who merely react to demand surges.

The choice of algorithmic class has strategic significance across the supply chain. Douaioui K. [3] argues that machine and deep-learning methods offer advantages under nonlinearity and high-dimensional trading data but require architectures that account for interaction networks and the temporal structure of demand. Extending this logic, Niu T. [8] shows that graph convolutional networks, which aggregate topological ties among chain nodes and their dynamics, improve forecasting accuracy for "distributor–retailer" relationships—critical when demand trajectories shift abruptly. At the same time, the sources of "viral" spikes arise within commercial practice itself. Gu Y. [4] shows that live streaming strengthens purchase intention via mechanisms of instant engagement and social proof, producing

steeper demand fronts. On the supply side, the chosen scheme for live streaming affects the distribution of risks and incentives. Li T. [6] shows that with a low commission rate an agency arrangement is preferable, whereas with a high commission rate a resale option is rational; participation by key opinion leaders increases audience trust, while algorithmic solutions reduce coordination costs. On the consumer side, Merritt K. [7] finds that the perception of live streaming in British retail is generally positive, confirming the channel's robustness for demand generation.

A key behavioral mechanism on the buyer side is uncertainty about the seller. Al-Adwan A. [1] shows that reducing seller-related uncertainty mediates loyalty and purchase intention in social commerce, thereby increasing the conversion of spikes in interest into transactions and stabilizing short-term demand dynamics. At the level of the research agenda, Dincer C. [2] documents growing attention to interdisciplinary models of engagement, reflecting a shift from isolated study of content to joint analysis of network effects, trust, and logistics.

Medium-term planning for live-streaming formats requires models that combine signals from interaction streams and sales histories. Zhang Q. [11] shows that a transformer-based temporal architecture is well suited to cross-border trade scenarios with high variability, where both seasonal patterns and sudden peaks induced by digital events matter. At the platform data-exchange level, Li J. [5] shows that horizontal schemes with data separation among participants can improve forecasts without centralizing confidential information, preserving robustness and scalability.

Reducing forecast error opens a practical window to align procurement, production, and distribution with short-lived yet intense waves of demand. The magnitudes of improvements and comparisons across model classes are presented below. Taken together, the results point to the need for an integrated architecture: network models for early prediction of content "viralness," forecasting methods that account for supply-chain topology, and organizational decisions in live streaming aligned with sellers' risk positions and audience expectations.

Contemporary research on demand forecasting in e-commerce and social commerce shows high effectiveness of algorithmic solutions, yet their application entails several constraints. One key limitation is the narrowness of the empirical bases used. Much of the literature relies on samples tied to Chinese social networks such as Weibo, the U.S. e-commerce market, or British retail [2]. This geographic and platform concentration risks limited transferability of findings to other social and institutional contexts. For example, the results of Douaioui K. [3] that record anomalous demand growth in the United States during the pandemic cannot be directly interpreted for developing markets with different levels of digitalization and logistics infrastructure.

Scaling federated-learning methods is another significant challenge. Li J. [5] shows that horizontal distributed-forecasting models provide higher accuracy without data centralization, yet real supply chains face technical and organizational constraints. High participant heterogeneity—from global marketplaces to small sellers—reduces protocol coherence for data exchange and limits opportunities for practical integration.

No less important are the difficulties of deploying graph neural models in real production pipelines. Niu T. [8] shows that graph convolutional networks reduce forecast error compared with classical models, but practical implementation requires a unified representation of supply-chain networks and substantial computational power. This constrains large-scale use in transnational logistics systems marked by data gaps and high variability in exchange rules. Comparative accuracy results are summarized in Table 3, which shows that the proposed graph model substantially outperforms ARIMA, SVR, and neural architectures (MLP, LSTM) on RMSE and MAPE metrics [8].

These data indicate that graph-based methods enjoy a durable advantage over traditional and neural approaches, especially under moving-average smoothing. However, even high forecast accuracy does not eliminate scaling problems. Integration must be adapted to real supply chains where data-transfer delays, information asymmetries, and institutional barriers are present.

Methodologically, a promising direction is the development of multi-model architectures that combine the strengths of different approaches. Integrating federated learning, graph models, and temporal transformers makes it possible to simultaneously account for the network structure of demand, data confidentiality, and long-term temporal dependencies. Zhang Q. [11] shows that transformer models are well suited to cross-border trade scenarios that exhibit both seasonal patterns and sharp spikes in interest. Together with the findings of Li T. [6] and Merritt K. [7] on live-streaming formats as demand triggers, this provides a basis for integrated forecasting systems in which the analytical model becomes part of a broader social-commerce ecosystem.

Table 3: Summary accuracy of demand forecasting methods (Compiled by the author based on: [8])

Algorithm	RMSE (Origin)	MAPE (Origin)	RMSE (7-day MA)	MAPE (7-day MA)
ARIMA	4.172	10.681	1.324	3.430
SVR	3.854	10.719	1.863	5.155
MLP	4.221	10.868	1.880	4.873
LSTM	4.594	12.053	3.003	7.849
Proposed GCN	3.298	8.562	1.334	3.370

In sum, current approaches are constrained by narrow empirical bases and algorithm-scaling challenges, while prospects lie in developing hybrid systems that combine the accuracy of graph methods, the distributed nature of federated learning, and the predictive power of transformer architectures. This direction opens a path to building resilient supply chains prepared for viral demand shifts and capable of reducing systemic risks in digital commerce.

V. CONCLUSION

This study establishes the central role of predictive analytics in managing viral demand in social commerce, demonstrating its importance for increasing seller engagement and preparing supply chains for sharp fluctuations in consumer interest. Predictive analytics should be viewed not as an add-on to digital platforms but as a foundational element of their architecture, shaping long-term resilience and competitiveness. Contemporary algorithms—including graph convolutional networks, federated learning, and temporal transformers—deliver higher forecasting accuracy than classical statistical models, which is particularly important for short-term demand spikes and high-dimensional digital data.

Predictive analytics functions both as a technological instrument and as a factor in the strategic interaction between platforms and sellers. Its use reduces uncertainty, strengthens trust in digital channels, and enables adaptive engagement models in which live-streaming organizational schemes and social capital play key roles. It is confirmed that forecasting accuracy directly relates to the ability to convert short-term spikes in interest into manageable transactions and stable relationships within the digital ecosystem.

Comparative analysis of algorithms shows a persistent advantage of graph models over traditional and neural methods; however, practical integration is accompanied by challenges of scaling, data asymmetry, and institutional barriers. This underscores the need for hybrid architectures that combine the strengths of different approaches while balancing forecast accuracy, data confidentiality, and the robustness of logistics processes.

Empirical results from TikTok Shop and Amazon Ads demonstrate that predictive analytics delivers both theoretical and practical benefits, expressed in increased engagement, improved supply-chain reliability, and preserved turnover. This confirms its strategic status for modern trading platforms.

There is a strong rationale for incorporating predictive analytics into the systemic toolkit of social-commerce platforms and seller strategies. This toolkit extends beyond a supporting forecasting function and becomes an independent mechanism for building competitive advantage, minimizing the bullwhip effect, and ensuring readiness for viral demand shifts. Future research should expand the geographic scope

of empirical bases, standardize integration protocols, and develop multi-layer models that combine macroeconomic forecasts, network effects, and behavioral analytics.

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