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Optimizing Retail Performance: Cloud-Enabled Big Data Strategies for Enhanced Consumer Insights

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Research has revealed the big data portfolio of retailers has four broad themes: supply chain, products or operations, competitive intelligence or customer relationships, and consumer or social . Most of the current retail big data applications have a clear focus on the competitive intelligence or customer relationships theme. Retailers understand big data more in terms of customer data, essentially CRM data. Examples of CRM data research include customer segmentation based on loyalty data, competitive intelligence applications employing spatial data, and big data analytics focusing on shopping basket or web data.
The retail environment is also home to a wealth of other types of data, but they are scarcely investigated potentially due to the lack of availability of third-party or secondary data sources. The topics remain on data that are owned by the retailer such as disaggregate sales data. Levels of aggregation in sales data research vary from region-years to hourly and from store-years to individual item-days. Examples include the applications looking for the impact of weather conditions, locations, or seasonality on retail sales. Another big data research strand involves social and consumer data with a focus on the identification of consumer opinions, activities, or mood or on the prediction of moviegoers (0 or 1 classification) liberal or conservative. Some of the recent applications have considered near-future values of economic indicators, such as the total number of tweets about tech companies as of next quarter.
Keywords: Retail performance optimization,Cloud-based big data,Consumer insights,Data-driven retail strategies,Cloud computing in retail,Big data analytics,Retail analytics solutions,Consumer behavior analysis,Cloud data storage,Retail performance metrics,Predictive analytics for retail,Real-time data processing,Data visualization in retail,Cloud-powered business intelligence,Retail data intelligence.

1. Introduction

In the 21st century, retailers face significant challenges in understanding their customers and gaining business insights, prompting a paradigm shift from the traditional mode emphasizing products and services to the new mode focusing on consumer-centric innovations. A powerful strategy to fulfill this goal consists of the ability to harness cloud-enabled big data technologies to gain insights from a large variety of structured and unstructured sources – at the moment they are produced – with networked, cloud-based, scalable system structures that permit real-time data filtering, processing, correlation, and alerting.

To discern the value of environment-oriented insights for a retail operation, an interdisciplinary framework is proposed that integrates retail store performance with consumer mobility insights. An experimental setup is introduced to collect temperature, relative humidity, and illumination data together with retail store performance microdata and subway station passenger records. A multi-strategy big data approach is designed to glean in-depth insight, combining correlation analysis with enhanced econometric models and neural network estimation of store-level sales based on consumer mobility feature representations.

The continued advancement of Internet technologies and devices are reshaping the way that businesses interact with consumers and conduct day-to-day operations, and these technologies are facilitating the generation of ever-larger volumes of real-time data. These so-called “big data” are characterized as multi-structured and time-variant, and have the potential to deliver a new value in terms of their veracity, variety, and velocity .

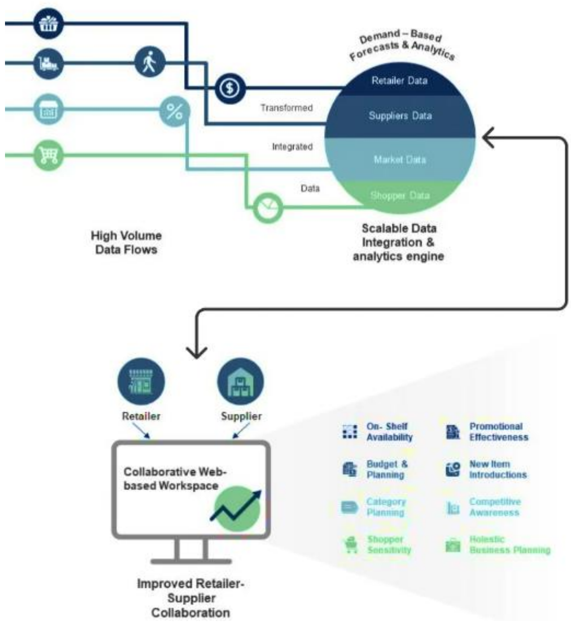

Fig 1: Big Data Analytics In the Retail Industry

2. The Role of Big Data in Retail Performance Optimization

Emerging applications in big data analytics have created a new basis for competition and growth in the retail sector. The rapidly growing volume of data with complex formats has increased the need for analyzing this data in a timely and cost-effective way. Analysis of historic data on sales and customer behavior enables new business strategies, such as micro-targeted campaigns, making product recommendations based on the consumer’s in-store activity, or real-time promotions and offers to clear stock before the end of the season. In addition to historical data, there may be another large source of in-store digital data produced by connected devices and sensors. The rapid development of digital technology is transforming the fast moving consumer goods (FMCG) retail sector and is set to expand into all areas of economic activity. Already, 4.4 zettabytes of data are being created every day and this pace is accelerating. Such a huge volume of data has the potential to provide insights into many areas of economic life. With the use of new technologies to store and process data, it became possible to use the vast amounts of digital data produced on a daily basis.

The use of big data in the retail sector will be examined, as this sector is characterized by a huge volume of data produced on a daily basis by connected devices, sensors, and mobile applications. As a result, it is a relevant test-bed ecosystem for the development of big data tools and applications connected with the analysis of this data. Four main themes of such applications in retail logistics will be identified: availability, assortment, pricing, and layout planning. A considerable amount of data is being generated on a daily basis by connected devices and sensors.

Fig 2: Big Data Analytics in Retail

2.1. Defining Big Data in Retail

The availability and affordability of data processing technologies and methods have allowed the collection, management and processing of data with unprecedented volume, velocity, and variety. The phenomenon itself has come to be referred to as big data across many different areas, including the retail sector . Over the years, the increasing interconnectedness of data has been consistently exploited by companies and governments to detect patterns, segment populations, make predictions, or even allocate resources. Efforts to exploit data have been greatly intensified, and at a faster pace, since the popularization of the internet. Public and private organisations invest heavily in the development of infrastructures, algorithms and processes to effectively and efficiently process data. Meanwhile, the penetration and evolution of technology has improved the capabilities and sophistication of data capture. As a result, data generation literally exploded. This data deluge, combined with falling costs of data management and processing, has further stimulated firms across sectors to harness big data for their operation. Although big data refers to a continuously evolving field, the convergence of leaps in data and technology within the last two decades propelled research on the topic to previously unimaginable levels. Topics such as the potential added value of big data analytics, its implications for economic growth, the predictability of social systems, the accuracy of population profiling and individual targeting, or the security and privacy of data have sparked a huge and diverse body of literature. Commerce has historically been a rich avenue for the weighing, measuring, and recording of transactions, and the rise of mass literacy, retailing, and manufacturing in the nineteenth century promoted data collection in Britain and the US. Likewise, data analytics play a significant role in the marketing aspect of a product, improving knowledge on consumer demand, uncovering target markets, identifying preferences, tracking trends, or price setting. The commercial evaluation of data in recent years is particularly noteworthy in Australia as a growing site for investment in big data.

Equ 1: Prediction of Customer Lifetime Value (CLV)

$$\mathrm{CLV} = \sum_{t=1}^{T} \frac{(R_t - C_t)}{(1+d)^t}$$

Where:

- R_t = Revenue generated from the customer in time period t
- C_t = Costs associated with the customer in time period t
- d = Discount rate (accounting for time value of money)
- T = Total number of periods for the customer

2.2. Benefits of Big Data in Retail

The variety, velocity and volume of data production associated with point-of-sale technologies, loyalty card programs and ecommerce applications have increased significantly in the retail sector. This is supplemented by connected devices such as inventory counters on stock shelves, radio frequency identification (RFID) tags embedded in products and Wi-Fi localization. As a consequence, many retail firms are innovating their existing retailing activities by implementing big data tools and applications. Given the data-intense nature of retail operations, the retail sector represents a relevant testbed for big data tools and applications. This has motivated the attention that has been generated in this branch of the literature.

Regarding this background, four themes have been identified for big data applications in the retail sector: availability, assortment, pricing; and layout planning. Historical sales data and loyalty schemes can be used to obtain valuable customer insights for operational planning. For example, promotional offers to increase sales, discounting end-of-life products or dynamic pricing schemes may impact consumer behavior. Turning their exit intent coupon campaigns into dynamic pricing campaigns, they have seen a 24% boost in conversion rates. Nevertheless, external data availability has expanded far beyond what has traditionally been used in the retail sector. Recent works point to the ability to exploit publicly available retail data, such as Twitter and Google Trend to better understand the structure and dynamics of the retail market.

3. Cloud Computing in Retail

One of the most important assets of every retail chain is knowledge about their business environment – consumers. Initially, what types of goods and services are expected to be most successful has to be determined. Further on, the store has to be placed in the most strategic location and designed in the most effective manner. Comfortable shopping environment, a friendly shopping assistant and a good price are the overall determinants at this point. However, maximizing sales in retail extends far beyond setting appropriate prices. Goods have cycles of popularity and they may differ by season, month, and day. At the same time, consumer's shopping activity emerges to be unforeseeable. That's when the need for the most optimal demand prediction indicators becomes the answer.

What is common among all these tasks is that they stand for analysis of a vast amount of data. A viewpoint could be missed even in this sea of data, which would bring the competitive edge of the store chain as an outcome. In addition to that, being able to perform these tasks on-the-fly, within minutes, translates into a possibility of instantaneous adjustment of the business strategy. At this edge, the state-of-the-art in terms of cloud computing emerges to the scene. Essentially, the results of cloud-era retail analytics target the availability of one big data cloud for data storing and manipulation .

Fig 3: Cloud Computing in Retail

3.1. Overview of Cloud Computing

Cloud computing has three forms, consisting of software-as-a-service (SaaS), a pay-as-you-go rental model where applications are available on the cloud, infrastructure-as-a-service (IaaS) allowing clients to instantly provision servers and storage on the cloud and run arbitrary operating systems without using the client's own server and platform-as-a-service (PaaS) allowing clients to deploy their own web applications on cloud, such as web server and database on the cloud. There are three cloud service models and a cloud service system is a set of elements that facilitated the development of cloud applications. The three main service delivery models are: 1. Infrastructure-as-a-Service (IaaS) The client organizes the operating systems, applications, storage, and network connectivity, but does not control the cloud infrastructure. The authorized service is provided to the consumer for processing, storage, networks, and other fundamental computing resources where the consumer can set up and run arbitrary software, including operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and limited network settings, for example, selection of firewalls. 2. Platform-as-a-Service (PaaS) The client has authority access to the platforms, enabling them to deploy their own software and applications in the cloud. Operating systems and network access are not managed by the consumer, and there might be constraints as to which applications can be deployed. Clients can deploy onto the cloud infrastructure consumer-created or acquired applications created using supported programming languages and tools. The client does not organize the underlying cloud infrastructure, but has control over the deployed applications and possibly application hosting environment configurations. 3. Software-as-a-Service (SaaS) Cloud computing provides businesses with unique capabilities to store data and run applications at off-site cloud data centers. Operation simplicity – users do not worry about maintaining or updating anything .

3.2. Benefits of Cloud Computing in Retail

Cloud computing provides the opportunity to forget the difficulties of installation, deployment, and maintenance of an IT system in the shops. Web-based services typically employ hundreds or even thousands of servers in the cloud for hosting the web service and the websites. These services have been managed by the firms that give them the opportunity to simply use them. Cloud computing helps retailers to be competitive in the market by aligning costs with actual use and eliminating the overhead costs of ownership. Supply chain operations are a popular area within the retail sector for cloud analytics and can gain improvements in turning, items ordered, and customer experiences . Retailers can benefit from low development, test and deployment costs of elasticity that clouds offer them. Actions requiring heavy computational power as well as demand increases in a short time can be supported. Action can be taken at a fraction of the cost of private clouds. High volumes and heterogeneous data can be collected from many sources and then be analysed at relatively low costs. Retailers can use external scalable clouds as a completely dedicated departmental decision support platform or narrow specific function solution in any merchandising, POS, CRM, e-commerce area and data analysis.

Equ 2: Sales Forecasting with Time Series Analysis

$$S_t = \alpha \cdot S_{t-1} + \beta \cdot X_t + \epsilon_t$$

Where:

- S_t = Sales forecast for time t
- S_{t-1} = Sales from previous period
- X_t = External factors influencing sales (e.g., promotions, holidays)
- α, β = Parameters for weighting
- ϵ_t = Error term

4. Integration of Cloud Computing and Big Data in Retail

Congratulations to the experienced investor for successfully surviving the latest global financial disaster. However if the investments of the warehouse chain do not maintain a sense of competition and survive through the implementation of technology strategies, then the past survivor performance is useless. To this end, there is the proposal of a new strategy for the optimization of retail performance, which is built on the integration of cloud computing and big data. For this purpose, a framework is presented to grasp global consumer insights, especially useful for strategic dynamic location decisions. The framework presents an overview of the random process and retail performance model, and subsequently introduces fundamental basic models of consumer visits. After the review of related works, detailed mathematical models will be developed for the elasticity of retail stores because of detecting the percentage of excessive offers.

As market revenue competition hots, competitive investors or companies make locations the first priority for initial strategic investment. It, hence, represents the significance of a new store location decision by means of outperforming a rival. Past literature, based on consumer behavior and observable data, hence developed a large quantity of methods and models to optimize the retail environment. However, with the fashionable cheapening and popularization of technology, the global consumer activity dataset can easily be collected due to the development of sensing devices, which can retrieve consumer and object data for big data analytics. This rapidly develops in many places like stores, shopping centers, and even a city center with pedestrian visits . On the other hand, though the cloud is somehow to make access to these data easier, some investors still have frequent analysis tasks and do not keep up with the economies of infrastructure. This drawback and the significance of cloud analytics are to encourage corresponding studies about the use of the cloud-ready big data strategies to generate comprehensive consumer insights for the competitive investors or companies.

4.1. Challenges and Solutions

The ROI for retail sector implementation of a recently prototyped cloud-based open platform for big-data enhanced customer analytics is characterized. Retailers are now under the spotlight to increase their performances in order to survive. A model is presented which increases the data preparedness for on-cloud processing and analysis, and a theoretical threshold model determines the minimum number of retail traders required to increase performances. A deficit in terms of the increased trading activity is found to within 10% of the critical value set by a retailer. This determination indicates that the retailers approaching the threshold are harmed via augmented inter-competitions. Despite using a market model for the sake of presentation, the threshold value is found to persist with more challenging market models that implement non-price trends. It is shown that the onset is nearly unaffected with unrestricted trade capacities, and that it is intrinsically related to the size and type of retail stores. Augmented realism in the models in terms of calibration of model parameters with financial data is also found to have minimal effect in terms of onset determination . Data-related trust issues in customer analytics service provision to retail small and medium enterprises are pointed out. A lack of readiness for big-data usage in retail SMEs is characterized. Addressing those trust-related and data-preparedness issues in terms of the presented cloud-based customer analytics service system is expected to enhance the effectiveness of the improved retail performances .

Fig 4: Big Data Challenges

5. Case Studies and Best Practices

The technology of capturing and analyzing vast amounts of data – so-called big data – has been around for a while. However, because of the nature of the consumer industry, the place where the goods change hands from producer to consumer, there are still limited cases of application in the retail and consumer goods industry . There are, indeed, some successful cases. However, these success stories come from large company groups, for which making investments in big data processing and analysis is affordable. That is why there is a need to develop new strategies to make this technology more accessible to all the companies in the supply chain. These include adaptation of the technology to the suit of small and medium-sized enterprises (SMEs) at an affordable price. For this, there is a need for an "open" cloud-based solution which will store the accumulated data of the customers at the SMEs, analyze it at a cloud-server and upload it back to the company. This will be platform-independent for the SMEs, enabling them to download and analyze their data-store and processed data-display at every compatible device. Some easier-to-manage steps can be taken, such as the employment of a high-capacity data capture device which will synchronize with the tills and store the accumulated data-store for a given period, and the employment of a simple tool which will upload customer list logs to a cloud-server. These lists can then easily be compared with the data-store available at the server to estimate the performance of the former big data processing tasks. On top of this, a set of nominal customization options can be defined by consulting with the SAME.

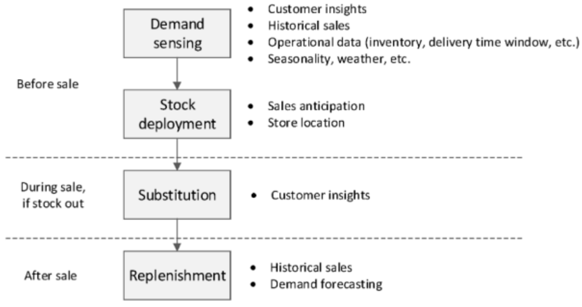

Fig 5: Big Data Practices in Retail Sector

5.1. Successful Implementations in Retail

Looking at present practices revealed that freight transportation, inventory management and order picking are the dominant big data themes in retail logistics, while technology improvements and potential impact on business practices are among the most fascinating ideas. Big data applications can contribute to a more responsive and efficient inventory system. Big data can be used for demand sensing and broad business coordination in order to make the supply chain more responsive to dynamic conditions. Historical Twitter feeds in a prototype are processed to quantify the impact of zeitgeist on demand or weather on operational disruptions, respectively. Although these present practices are not widespread yet, following numbers suggest that retail companies are likely to invest significant resources into it soon. Use of real time transport sensors, real time environmental sensors or drones is expected to increase by 350% in the next 0–3 years. Artificial Intelligence, predictive algorithms, location based marketing, as well as telematics and vehicle management software yield the highest benefit in big transport companies shipping a lot to stores. In the context of the European retail and logistics landscape, it is worth noting that digital innovation and e-commerce have become key priority areas of research and development. Across Europe, one in ten shops are empty and 70% of shopkeepers have less than ten employees. Further, on average, 50% of shop-keepers are 50 and older, leading to a generational challenge in the sector. Modern retail policy therefore needs to support sustainable retail practices. Given the current low market presence, SME strategies should build on digital innovation. It is, however, much supported by policy and there is a need to build up business support measures at local level. There are also structural changes at the demand side. Younger generations are moving to bigger cities, have continuous internet access and high expectations of sustainability. They are also linked to new consumption trends including lack of car use and less use of traditional retail. Two distinct strategies designed to stimulate the audience's emotional response to online advertisement are identified.

Equ 3: Dynamic Pricing Optimization

$$P_t = f(D_t, S_t, C_t, \text{Competitor Pricing})$$

Where:

- P_t = Optimal price at time t
- D_t = Demand at time t
- S_t = Supply level at time t
- C_t = Cost of goods sold at time t
- **Competitor Pricing** = Prices set by competitors for similar products

6. Conclusion

The technology for handling big data is now available, but traditional retailers have been slower than many other types of use to exploit this tool for enhancing their business operations. Can retail operators afford to be left behind before the rest of the business community? One way to improve the situation is to enlighten retailers by showing them how access to big data and cloud resources can be used to enhance insight into their consumers' shopping behaviours.

A major application that has been harvesting big data since long is the retail business. There is a wide availability of customer and demographic details, electronic financial transactions, and electronic storage and shipping details that allow bi-directional traceability of the product. This data can be effectively utilized to obtain insights into business operations, enhance consumer service, and develop targeted advertising and personal promotions . The pressure to improve retail performance is rising, leading many business corporations to both exploit cloud and big data technologies in order to improve their competitive edge.

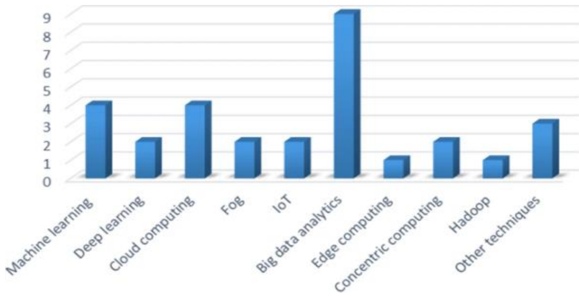

Fig 6: A brief survey on big data: technologies, terminologies and data-intensive

6.1. Future Trends

The development of e-commerce has brought much convenience to our lives. With the emergence of various online shopping platforms, the number of daily opportunities for purchasing has gradually become oversized, giving customers the advantages of choosing, comparing, and even sealing deals from any place and at any time. However, with the e-commerce industry thriving, the emergence of "big boxes" has also placed strong pressure on physical retailers, leading to reductions in offline purchases. As a result, an increasing number of companies, particularly start-ups, have gradually opted to accept the opportunity to provide online and offline collaborative sales strategies like one-hour packages, pop-up shops, and ten-minute housekeepers and fruit potatoes. In addition, retail data can be given a new value through the deployment and analysis of big data technologies, thus improving the store's climate, traffic routes, designs and goods, so as to attract more people into the physical business premises . The current study hopes to provide retailers with a deeper understanding of adopting relevant physical data collection devices based on clustering technology, as well as the analysis of the actual potential in winning the loyalty of customers to improve the store's income and ultimately enhance profitability. There are a growing number of intelligent resources currently provided due to the improvement of IoT technology. However, when beginning to use smart equipment technology for in-depth user behavior surveillance in shops, companies frequently face two issues that need to be addressed: 1) Exactly where should smart devices be installed in the store?; 2) How might the data collected by IoT technology be analyzed? With regard to these, due to the limited number of tools and testing, it is expected that the use of a limited cost to obtain the largest increment in the profit of the store would be impossible.

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