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Using Big Data Analytics to Optimise Inventory Management in the U.S. E-Commerce Warehouses

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ABSTRACT

This study examined how Big Data Analytics (BDA) can be used to optimise inventory management in the warehouses of the U.S. e-commerce companies especially targeting Small and Medium-sized Enterprises (SMEs). With the fast digitalization of logistics, a large number of SMEs are having difficulties with integrating BDA because of resource shortage, technical capability, and an inability to quantify the profit. The research was anchored on the Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) assessing the level of BDA implementation, the effect it had on inventory performance as well as the barriers and enablers to its implementation process. Quantitative survey was employed, where 343 inventory managers, analysts, and supervisors in Illinois provided data, which was analysed using SPSS version 27. The results indicated that BDA is very popular with a great impact of improvement in inventory turnover, stock accuracy, and consequential order fulfilment time and a good beta coefficient of 0.358, which reflects positive effect being moderate. Among the key obstacles, the integration challenges were listed, as well as high costs and low availability of skilled workforce, whereas the major enablers were stated to be support of top management, robust IT base and training of the employees. BDA is both strategic resource and dynamic capability that ensures agility and competitiveness. The study recommends that the SMEs make investments in the development of their workforce and IT modernization. Also, policymakers should offer incentives to facilitate the reduction of adoption prices. Longitudinal and cross-sector research studies should be studied in future academic research.

INTRODUCTION

In the last ten years, the digital economy has transformed the scenario of logistics and retail by creating a more detailed, speedier, and data-dense version of commerce. According to Yusof (2024), the traditional method of inventory has become less relevant in forecasting the consumer demand in the digital marketplace that is high volume, real time and volatile. Inventory Management describes the proper method of acquiring, storing, and selling stock of raw materials and finished products in an adequate quantity and at the appropriate time (Sah & Furedi-Fulop, 2022). Ali et al. (2024) indicate that this digital era has seen inventory management to be much more than just stock takes and reorder points. It covers the maturity of the capability to predict accurately, to control stocks, to control fuel flow across the supply chain as it happens, and to automate stock decisions (Madamidola et al., 2024). With this change, Big Data Analytics (BDA) has emerged to bring about intelligent inventories. BDA is the tools and procedures that are employed to collect, curate and analyse massive amounts of structured and unstructured data to make business decisions based on that data (Ikegwu et al., 2022). Analytics help in the inventory systems so that organisations transform reactive management of the inventory into predictive and proactive strategies (Al Bashar et al., 2024; Yusof, 2024). Consequently, inventory management is not only more efficient but also more capable of responding to real-time changes in customer behaviour and supply chain impacts. Firms like Amazon and Walmart have blown up in terms of operational efficiency because they both spent heavily on data analytics and artificial intelligence (Kuandykov, 2021; Salmon et al., 2021). This has allowed them to optimise inventory flows and prevent any errors in fulfilments. Moreover, the U.S. warehouse industry is transitioning to an accelerated process of digitisation because of the expansion of IoT, RFID, and cloud-based stock administration (Ilandarage, 2025). (Tubis & Rohman, 2023) further adds that big amounts of real-time analyses and data that are generated by such systems contribute greatly to making the decisions in inventory planning, storage and distribution more efficient. Thus, BDA is perceived not only interchangeably as the digital component of supply chain technology but, more importantly, as the digital supply

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chain accelerator of the digital economy (El Haddad & Salah Hassan Abdel Baqi, 2022). Nevertheless, in the case of optimisation of inventory, especially in e-commerce warehouses, its application remains little studied. E-commerce warehousing is so dynamic and unpredictable that it tends to become difficult to support the classic inventory systems, that is, numerous orders, just-in-time situational demand, expedited delivery, and shipping to doors (Allioui et al., 2024).

Also, the existing literature is limited to such large multinational companies as Amazon and Walmart because it has the necessary infrastructure and can afford a sophisticated data analytics tool (Sanders, 2016). Possible barriers such as unavailability of sufficient finance, less technical skills, and coverage of data curtail the ability of the SMEs to implement and adopt the use of BDA tools in the management of inventory stock (Maroufkhani et al., 2023; Nasrollahi et al., 2021). As such, the gap in the market is the absence of an inclusive research on the issue of how the SMEs can utilise big data innovations that are scalable and cheap to ensure that the performance of their inventory is enhanced within their warehouses. Moreover, under the inventory decisions, not only the terms of profitability, but also the indicators of supply chain balance, the spoilage of products, excess stock, energy, and material waste due to overstocking or perishing (Genovese et al., 2017) are impacted. Considering environmental integrity in managing inventories, it is possible to make firms adopt a sustainable practice and reduce the overall effect on the environment. This is because the consumers and authorities are increasingly becoming progressive regarding sustainable logistics processes (Kolasińska-Morawska et al., 2022). Thus, with such gaps, empirical and conceptual research is needed, in terms of how big data analytics can be applied to manage the inventory of the U.S. e-commerce warehouses in the most ideal way. Such research cannot solely be understood in relation to technical performance measures, but instead it must take note of the situation experienced within an SME organisation and examine the environmental consequences of inventory decisions motivated by BDA. This gap is an important factor in the design of more resilient, inclusive and sustainable e-commerce supply chains. Therefore, this study seeks to (1) evaluate the extent to which big data analytics applies in the inventory of e-commerce warehousing in the U.S.; (2) analyse the impact of big data analytics on some of the important inventory performance measures and (3) determine the obstacles and facilitators preventing the implementation of big data analytics by SMEs that run e-commerce businesses in the U.S.

LITERATURE REVIEW

Theoretical Review

Resource-Based View

Resource-Based View (RBV) is a postulation attributed to Barney (1991) credited to ideas portrayed by Wernerfelt (1984). RBV states that a company competitive advantage happens because of its ownership of resources and the ability to use them effectively which are valuable, rare, inimitable, and non-substitutable. The RBV has widely been used in the field of literature to describe the results of technology adoption and digital transformation. An example includes a study conducted by Wamba et al. (2017) who held the argument that the Big data analytics capabilities are strategic organisational resources that lead to the enhancement of supply chain performance and operational efficiency. Nearly in the same direction, Akter et al. (2022) employed RBV in their study to explain why companies that implement enhanced analytics of big data can provide better inventory turnover and customer satisfaction. Gupta et al. (2019) used RBV to determine how data platforms and analytics infrastructure present competitive advantages in quick-response markets unique to other e-commerce corporations. BDA is useful in improving inventory decisions, is lowly adopted by SMEs, cannot be duplicated because of firm-specific data sets and model customisation, and cannot be substituted by the old methods to work (predictive analytics). RBV, therefore, qualifies BDA as a strategic resource that answers the question why e-commerce companies that incorporate analytics do a more efficient job in optimising inventory, being responsive and competitive in the modern digital economy.

Dynamic Capabilities Theory

The Dynamic Capabilities Theory (DCT) was proposed by Teece et al. (1997) to complement Resource-Based View because it focuses on the capacities of a firm to integrate, create, and recombine both internal and external resource to react to environmental dynamics promptly. This theory was further advanced by Teece (2007) who

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claimed that in the harsh markets, the mere possession of highly valued resources is important but also the capacity to adapt, renew and reconfigure resources so as to attain sustained competitive advantage. DCT has also been commonly employed in extolling the reaction of organisations to technological disturbances and market dynamism in literature. Wamba et al. (2017) and Dubey et al. (2021) employed DCT to demonstrate the role of Big Data Analytics (BDA) capabilities that help firms' sense, seize, and transform operations and achieve improved supply chain agility. The applicability of the theory is related to the fact that e-commerce warehousing implementation is on the one hand exposed to conditions of very dynamic demand and fulfilment, and therefore data resources are not sufficient when it comes to expedient real-time reconfiguration of inventory. Deployment of DCT allows to realize how companies utilize BDA in predictive modelling, forecast demand and pre-emptive decision-making as a mean to gain their agility, resilience and competitiveness through such inventory management practices in the digital economy.

EMPIRICAL REVIEW

E-commerce and Warehousing, Inventory Management and Big Data Analytics.

Today, firms have adopted Big Data Analytics (BDA)to achieve their objectives in diverse aspects of their business models. With reference to the e-commerce domain, Jantapoon (2025) applied machine learning to SEM to provide evidence that advanced intelligent warehousing systems brings about a notable decrease in order fulfilment time and an increase in inventory accuracy rates. The results indicate how smart warehousing and IoT, analytics platforms and AI can balance the inventory levels with real-time change and improve utilisation and space, decrease common errors and uplift performance in the process of fulfilment. Another research study that presented a results-based study using structural equation modelling (SEM) on a survey carried out on 189 supply chain managers showed that the ability to use advanced analytics has a substantial impact on the quality of demand planning (Gunasekaran et al., 2017). Banerjee and Das (2025)also found that an organisation that relied on customer behaviour, environment data and past sales records was more likely to be successful in the unstable markets as compared to an organisation that was solely basing its plan on the traditional ERP-based planning systems.

Similarly, Choi et al. (2018) made the conclusion that companies, which applied real time analytics to their warehouse management system, operated with fewer inventory changes and a higher degree of awareness to fluctuating customer needs. Alonge et al. (2023) further adds that the availability of sensor-based technology, such as RFID and IOT, allows recording latest inventory information, which also directly feeds into BDA systems. Likewise, Sazu and Jahan (2022) established that when BDA tools were applied, especially using time series forecasting and clustering formulas, there was an increase in the reliability of the forecast of 15-25% in the study conducted on fast-moving consumer goods (FMCG) companies. As well, Hasan et al. (2024) indicated that the companies which shared BDA platform with suppliers and distributors were closer together in terms of realising stock levels together with their suppliers and clients (firms) that assisted in eliminating bullwhip effect. They also found out in their results that interoperability and transparency of data between the partners were required.

Inventory Performance Scores and Big Data Analysis

Inventory performance measurement and enhancement have been largely impacted by Big Data Analytics (BDA), especially in modern warehousing and supply chain management. In a cross-industry research by Wamba et al. (2017) found that companies that introduced predictive analytics and machine learning models published an increased inventory turnover rate and enlarged accuracy of stock. On the same note, Chen (2024) surveyed the firms operating in the manufacturing and retail business and established a positive relationship between BDA maturity and the markers of key performances, such as order fulfilment time, stockout rates, and holding costs. Dynamic capabilities, including the skills of data interpretation and alert IT structures, were considered significant mediators between BDA adoption and inventory performance of companies in the emerging markets (Mikalef et al., 2019). The result concurred with that of Dubey et al. (2021), who, using a multi-country sample, showed that the combination of analytics maturity and organisational flexibility influenced the achievement of the benefits of an inventory. Choi et al. (2018) also carried out a longitudinal study concerning the execution of the descriptive and predictive analytics application, and they concluded that

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BDA implementation resulted in a 15% decrease in the lead time variability and a 12% increase in the inventory turnover ratios. This is in relation to Radebe (2021), who observed that warehouse enterprises applying BDA reported a drastically decreased amount of stockouts and higher forecast precision than control organisations.

The Impediments and Facilitating Factors and the use of Big Data Analytics

Inasmuch as Big Data Analytics (BDA) has significant benefits in terms of inventory management and warehousing, its use has not been consistent in industries and types of organisations. According to the research conducted by Maroufkhani et al. (2023), SMEs are in a specific struggle to embrace BDA financially, as there is a small budget and a lack of understanding of the return on investment (ROI). Cost, lack of technical expertise and low perceived usefulness were the key factors that made adoption a barrier to among SMEs (Chouki et al., 2020). Tiwari and Khan (2020) reveal that the talent gap is one of the issues that considerably impede the BDA projects from overcoming pilot stages and becoming a full-scale level. There is also the problem of low data literacy level among warehouse and supply chain staff, restricting practical use of analytics tools to the extent that systems are underutilised, even when the systems have been implemented. Maroufkhani et al. (2020) note that analytics results may be distorted or inaccurate in the absence of a standard data format and a trustworthy data pipeline. Several enablers have, however, become key towards the success of BDA adoption with one being the top management support (El-Haddadeh et al., 2021). Gökalp and Martinez (2022)hypothesise that an organisation with a leadership that focuses on digital transformation and commits the needed resources would advance further in analytics maturity. In addition, adoption of resource-constrained firms has been supplemented through enablers which are external to the firm, specifically governmental incentives, industry partnerships and vendor support (El-Haddadeh et al., 2021; Gökalp & Martinez, 2022).

METHODOLOGY

Research Design

This study adopts a quantitative approach with a descriptive survey design, which is strictly determined through the adoption of this design to explore the detailed relationships between Big Data Analytics (BDA), inventory management activities, and the performance indicators relating to e-commerce warehousing. The descriptive survey design is of importance because it allows the researcher to exhaustively examine a great variety of measures linked with the inventory performance. At the same time, evaluating the set of enabling or limiting factors, which might affect the given measures, being very objective and providing adequate comparability between various companies. Taking the objectives of the research, the design assisted in gathering standardised, quantifiable information that is suitable to test the hypothesis and generalise the research across different organisational settings (Creswell & Creswell, 2017). Moreover, this choice of research design did not only allow treating the topic in question with a high degree of care, but helped to generalise the results of the research and apply them in other similar situations of e-commerce that are abundant in the vast market of the United States.

Population, Sample and Sampling Techniques

The specified target population in the study entailed a diverse sample of professionals, namely, inventory managers, warehouse supervisors, and data analysts, hired in the e-commerce businesses that, at the time, take advantage of or plan to implement Big Data Analytics (BDA) tools in the US. The Chicago metropolitan area and Illinois were selected to be the surveyed areas because of their extremely high concentration of e-commerce warehouses and logistics infrastructure that is well-developed (Gutelius & Theodore, 2019). Illinois is one of the production leaders in distribution centres and the implementation of digital freight services; thus, it provides an excellent setting to study Big Data Analytics (BDA) implementation and inventory outcomes (Lee & Mangalaraj, 2022). The stratification of e-commerce firms was done based on classification of the firms as small, medium and big enterprises and selection of individual participants within the specified stratum was done using a simple random sampling technique.

The study sample size was computed by use of the Yamane (1967) formula. Where:

n = number of samples

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N = sample populations

e = error margin

Thus, with this formula, the size of a sample was

n = 2400/1+2400(0.0025)

n = 2400/1+6

n = 2400/7

n = 342.86 = 343

The proposed target size of the sample is closer to 343 respondents, which is significant in a statistical sense and generalizable. Also, to minimise any bias that could arise, further intensive efforts were made to institute voluntary participation, ensure anonymity of the respondents and keep out the over-sampling of high-tech or large corporations that could, in effect, make the study end up unrepresentative.

Data Collection Instruments and Methods

A structured questionnaire was used to collect data in this study on the basis of validated instruments according to empirical studies. A well-organised questionnaire was created comprising four parts. They include (a) Demographic Firm data, (b), BDA adoption, where the items of this part were adapted from Wamba et al. (2017), who created strong BDA adoption measures connected to logistics performance. The items in this section (c)were modified based on the inventory performance indicators proposed by Maroufkhani et al. (2020), which permits assessing the effect of BDA on the objective inventory performance in an objective way. For section (d) which is the barriers and enablers to these BDA , items on this section were based on Gunasekaran et al. (2017) and Maroufkhani et al. (2020). These give an insight into the internal and external factors to the BDA adoption. The construct item responses were measured using a 5-point Likert scale (i.e. 1 = Strongly Disagree to 5 = Strongly Agree). It was targeted at inventory managers, warehouse supervisors and other workers/staff in the operation of the e-commerce companies. The distribution of the online survey instrument using Google Forms enabled the survey to reach different geographical locations and also easily participate in the survey. To be diverse, the respondents were contacted through professional networks, LinkedIn, and through mailing lists used in the industry.

Methods of Data Analysis

The analysis of data relied on SPSS (version 27). The demographics of participants and the pattern of distribution of a key variable were summarised by descriptive statistics (mean, standard deviation, and frequency). Moreover, correlation and multiple regression analysis was used to assess the predictive relationship between BDA adoption and inventory performance. Cronbach's Alpha was utilised to test internal consistency of the scales. To identify the extent to which the BDA adoption has affected the inventory performance, the study relied on multiple regression analysis.

Ethical Considerations

The nature of this research followed strict ethical guidelines, which were fully congruent with the research guidelines provided by the associated institutional authorities. Participation was voluntary with informed digital consent obtained before questionnaire access. The study participants were told that their names would not be disclosed and that their answers would be given the same degree of confidentiality to the extent that no identifiable personal data would be collected in relation to this study. Data was securely stored and used solely for research purposes. Moreover, ethical approval was obtained before data collection. Such precautions contribute to the credibility of the research but also play the role of contributing to the wider discussion of the ethical standards in the field of academic research.

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RESULTS AND DISCUSSION

Demographics

This section presents the demographic information from the respondents who participated in the survey. The section presents information on the role of the respondent in the organization, the size of the organization (which is the number of employees), the number of years the employee has been using Inventory Management Systems (IMS) and the years of experience of the respondent in supply chain. Table 1 below presents this information.

Table 1: Background Information of Respondents

Description	**Freq.**	**Percent**	**Description**	**Freq.**	**Percent**
Role in Organization			**No. of Years using IMS**		
Manager	105	30.6	Less than a year	18	5.2
Analyst	204	59.5	1 – 3 years	54	15.7
Supervisor	21	6.1	4 – 6 years	98	28.6
Others	13	3.8	More than 6 years	173	50.4
Size of Organization (Number of Employees)			**Years of Experience in Supply Chain**		
1 – 49	110	32.1	Less than a year	89	25.9
50 – 249	215	62.7	1 – 3 years	186	54.2
250-999	12	3.5	4 – 6 years	39	11.4
1000 and above	6	1.7	More than 6 years	29	8.5
N = 343					

The profile of respondents (N = 343) demographics gives an idea about their roles, organisational attributes and professional background. Analysts (59.5%) suggest that majority of participants are involved in data interpretation, evaluate and make operational decisions on behalf of their firms. The percentage that was in strategic and leadership positions was 30.6% and they were managers. The 6.1 percent made up supervisors representing mid-level operational supervision jobs, whereas 3.8 percent appeared in the Others category, which could presumably incorporate consultants, interns, or the personnel in the role unmentioned. Around half of the companies (50.4%) have had Inventory Management Systems (IMS) in service over six years which means that the integration of inventory system is mature in the process of these companies. The percentage of those who have used IMS between 4 and 6 years and 1 and 3 years are about 28.6% and 15.7% respectively which shows an increasing trend. The proportion that are reported as using IMS less than one year is only 5.2% indicating that there are not many new users. The majority (62.7%) of the respondents are employed in medium sized companies, and 32.1 percent are employed in small organisations. There are 3.5% of large organisations and only 1.7% work in the firms having more than 1000 employees reflecting the bias of the sample towards medium and small businesses (SMEs). More than fifty percent (54.2%) gained experience of 1 to 3 years which indicates the majority are relatively young career professionals. Moreover, 25.9% of respondents have less than one year and 11.4% have 4-6 years of experience and only 8.5% have over six years of experience. It means that the pool

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of participants is mostly constituted of new professionals in supply chain and inventory management.

Reliability Statistics

To determine the internal consistency of the questions in the questionnaire that this study applied, the reliability analysis was performed.

Reliability Statistics

Cronbach's Alpha	N of Items
.919	44

The results indicate that Cronbach's alpha is 0.919 on 44 items involved in the analysis. And this is good because a value greater than 0.70 is usually viewed as one that has very high internal consistency within a set of items that measure the same construct (Pavot et al., 1991). This high value of alpha implies that there are correlations between items in the questionnaire and that they are appropriate to reflect the dimensions of acceptance and implementation of Big Data analytics, inventory management performance, and other variables under the study. It means that respondents answered the items in the same way and hence giving a high credibility and dependability of the data collected.

Objective One: Extent to which Big Data Analytics Applies in the Inventory of E-Commerce Warehousing in the U.S.

The section presents data on the use of Big Data Analytics (BDA) in the current environment of inventory management in US organisations. The findings indicate, in general, that the use of BDA has become significant and firmly rooted in the decision-making operations in the e-business warehousing. Table 2 below presents the descriptive statistics of the extent to which BDA applies in the inventory of e-commerce warehousing in the U.S.

Table 2: Descriptive Statistics on the Extent to which Big Data Analytics Applies in the Inventory of E-Commerce Warehousing in the U.S

	N	Mean	Std. Deviation
Our organisation uses Big Data Analytics tools in daily inventory management decisions.	343	4.28	.768
Inventory-related decisions are supported by real-time data analytics dashboards.	343	4.05	.778
Data analytics insights are integrated into our inventory forecasting models.	343	4.16	.765
Our warehouse management system is connected to advanced analytics tools.	343	4.12	.833
We rely on predictive analytics to determine optimal reorder points.	343	4.20	.846
Our organisation uses data analytics to monitor inventory turnover rates regularly	343	4.39	.736

From Table 2, it can be seen that there was a strong agreement with the respondents believing that their organisations indeed apply the BDA tools in making inventory management decisions on a daily basis, with a mean of 4.28 and a low standard deviation of 0.768. It not only means that the degree of agreement is great, but also the degree of consistency between the respondents, that is, data-driven decision-making has become an ordinary component of the inventory management of most firms present in the sample. Applying predictive analytics towards the identification of optimum reorder points also had a high mean score of 4.20 (SD = 0.846). This means that organisations are using advanced analytics to regularly account for the level of goods and hence

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restock products before stocks hit near-empty levels. In the same manner, incorporation of data analytics knowledge into inventory forecasting models produced an average mean of 4.16 and a standard deviation of 0.765. It implies that companies not only utilise the past data, but are also engaging in implementing analytics to forecast the future demand, rationalise the inventory planning, and match the stock levels to the market dynamics. The study also found out that warehousing management systems (WMS) and sophisticated analytical tools achieved a mean of 4.12 (SD = 0.833), indicating that most of the firms have interconnected their working systems with analytics platforms to facilitate the sending of data and making of decisions. Interestingly, the lowest mean score in the items was the use of real-time data analytics dashboards, with a mean score of 4.05 (SD = 0.778). Whereas it is still high, this indicates that despite the fact that there has been mass adoption of dashboards, there might be some different depths and sophistication in using dashboards. Lastly, the statement with the maximum mean score among all items is the monitoring rates of inventory turnover on a regular basis using the concept of data analytics, recording a mean score of 4.39, whereas the standard deviation was 0.736. This observation puts more emphasis on the significance attached to the monitoring of turnover as a major performance indicator in the management of inventories.

The results indicate that Big Data Analytics (BDA) are extensively used in terms of inventory management of the U.S., e-commerce warehouses across the measures of mean numbers. Achieving higher rates of inventory turnover showed the greatest mean (4.39), which shows that companies are keen on data-based monitoring of inventory turnover rates. This is corroborative of Resource-based view (Barney, 1991; Wernerfelt, 1984) that holds that BDA capabilities are valuable, rare and inimitable and can therefore increase competitive advantage of the firm. The use of predictive analytics in the determination of the reorder points (M = 4.20) and forecast models (M = 4.16) also personifies the Dynamic Capabilities Theory (Teece, 2007), which notes the capacity of firms to reorganise resources as a reaction to changing demands of the markets. These findings correspond with those of (Akter et al., 2022; Wamba et al., 2017) who discovered that the adoption of BDA has a positive influence on the inventory planning and customer satisfaction. Nevertheless, another observation is that the mean score of real-time dashboards is not as high (4.05) in spite of the high overall use of BDAs, which may indicate that although firms implement the dashboards, not all of them are used in full scope. It implies that there is a possibility of additional learning and investment in decision-making in real-time. Therefore, this study reaffirms the fact that BDA is an internal strategic resource and dynamic capacity involved in e-commerce inventory management in terms of operational agility and competitiveness.

Objective Two: The Impact of Big Data Analytics on Some of The Important Inventory Performance Measures

This section presents the results on the impact of BDA overall adoption and integrations (GAI) on the different inventory performance indicators. The section first presents the correlation results showing the relationships between the independent variable and the dependent variables. Then a follow-up regression results is presented to examine the impact of the independent variable (GAI) on the dependent variable (IMP).

Correlation Analysis

The findings show that GAI is significantly and positively related to all five performance indicators. Thus, the greater the infusion and adoption of BDA, the better inventory performance. The outcome is shown in Table 3 below.

Table 3: Correlations

	GAI	IT	SA	OFT	CS	RS
GAI	1	.361**	.225**	.287**	.240**	.144**
IT	.361**	1	.377**	.324**	.308**	.242**
SA	.225**	.377**	1	.579**	.420**	.345**

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OFT	.287**	.324**	.579**	1	.428**	.326**
CS	.240**	.308**	.420**	.428**	1	.314**
RS	.144**	.242**	.345**	.326**	.314**	1
****. Correlation is significant at the 0.01 level (2-tailed).**						

From Table 3, there was a significant positive correlation between GAI and Inventory Turnover (IT) with a Pearson coefficient of 0.361 ($p < .001$). This means that organisations that adopt a greater extent of BDA have quicker cycles of inventory turnover, signifying a higher speed in moving stocks and in selling units. Also, GAI showed a positive correlation with Stock Accuracy (SA), which was lower ($r = 0.225$, $p < .001$). This means that the addition of BDA allows for an increase in the accuracy of stock levels registered to a lower degree than that of its impact on the turnover rates. There was also a positive correlation between GAI and Order Fulfilment Time (OFT) ($r = 0.287$, $p < .001$). The implication of this finding is that increased utilisation of BDA can be useful in reducing order processing time, possibly through better selection of picking, packing and allocation of inventory items. Moreover, the GAI showed a positive relationship towards the Customer Satisfaction (CS) on the product availability ($r = 0.240$, $p < .001$). This implies that those organisations which are better integrated with BDA are in a much better position to fulfil the demand of their customers, regularly leading towards increased levels of satisfaction. Finally, the relationship that was not in the strongest association with GAI, although still significant was that of Reduced Stockouts (RS) ($r = 0.144$, $p = .008$). This means that the BDA adoption does not play much of a role in coverage reduction in this case than in others, where its effect seems minor.

Regression Analysis

The regression analysis was performed in order to analyse the impact of the generality of the adoption and integration (GAI) of Big Data Analytics on the inventory management performance (IMP).

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.358[a]	0.128	0.125	0.42463	2.029
a. Predictors: (Constant), GAI					
b. Dependent Variable: IMP					

The model returned an R value of 0.358, which suggested that General Adoption and Integration of BDA and inventory performance showed a moderate positive relationship. This is an indication that the more organisations deploy and incorporate the use of BDA tools in inventory management, the better the inventory performance results. The R Square value is 0.128, so about 12.8%of the variance in the performance of inventory management can be attributed to GAI alone. Although this is a small percentage of explained variance, it is statistically significant in the operational and technology adoption study field, where the performance outcomes depend on several organisational and external factors.

Table 5: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.024	1	9.024	50.049	.000[b]
	Residual	61.485	341	0.18		

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	Total	70.51	342			
a. Dependent Variable: IMP						
b. Predictors: (Constant), GAI						

The model analysis indicates that the regression model is significant an F-value equal to 50.049 and a p-value less than 0.001. This implies that the overall model is a predictor of the inventory management performance. The regression sum of squares is 9.024, which indicates the degree of scatter in the performance indicated by inventory in response to an explanation provided by GAI. Conversely, the value of the residual sum of squares is 61.485, which means the unexplained variance and the total sum of squares are 70.510. The greater value of the F statistic reflects much higher variance explained by the model compared to the variance not explained by the residual. Therefore, the impact of GAI on inventory performance is statistically different, and it would be virtually impossible to be a result of chance.

Table 6: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.73	0.192		14.235	0
	GAI	0.321	0.045	0.358	7.075	0
a. Dependent Variable: IMP						

The unstandardized coefficient (B) of GAI is 0.321, having a standard error of 0.045. What this means is that as GAI increases by one unit, the performance of inventory management is also expected to go up by 0.321 units as the other factors remain constant. Beta coefficient is standardised at 0.358, which is indicative of a moderate positive relationship between GAI and inventory performance when the two variables are standardised on the same scale. It is explained that this value of beta is representative of how well the BDA adoption is associated with inventory performance compared to the other possible predictors that are not captured in this formula.

The p-value corresponding to GAI is less than 0.001, and the value of t = 7.075, which clearly indicates that the effect is highly statistically significant. This proves that GAI is a useful indicator of inventory performance in the sampled organisations. The results indicate that the adoption rate of Big Data Analytics (BDA) positively and greatly changes inventory performance metrics in U.S. e-commerce warehousing. The most significant correlation was with the inventory turnover ($r = .361$, $p < .001$), implying that BDA leads to a more effective movement of the stock, which corresponds to the conclusion of Akter et al. (2022) regarding the idea that predictive analytics lead to better turnover rates. The positive correlation with stock accuracy ($r = .225$) and order fulfilment time ($r = .287$) only confirms Choi et al. (2018) as BDA allows tracking inventory more accurately and faster. Moreover, customer satisfaction displayed a positive correlation ($r = .240$) and proved that data-driven inventory management increases service levels, as Gunasekaran et al. (2017) assume. The regression analysis proves that the use of BDA can explain 12.80 percent of the variance in sample inventory performance in which the beta value (0.358, $p < 0.001$) is statistically significant, accordingly, the Dynamic Capabilities Theory (Teece, 2007). This implies that the firms not only have the capabilities to run analytics but are also capable of redefining their operations in a dynamic way to address changes in demand. Though effect on reduced stockouts is more week ($r = .144$), it is significant, which means that we could improve on that matter. In general, the findings can contribute significantly to the current state of knowledge by offering reliable evidence based on SMEs of e-commerce since they confirm that BDA is both strategic resource and dynamic capability that improves agility, efficiency, and competitiveness in inventory management.

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Objective Three: The Obstacles and Facilitators Preventing the Implementation of Big Data Analytics by SMEs that Run E-Commerce Businesses in the U.S

The descriptive analysis offers information on the perceived inhibitory and enabling factors affecting the implementation of Big Data Analytics (BDA) in the organisations. The first table (Table 7) shows the barriers and Table 8 shows the Enablers as answered by the respondents.

Table 7: Barriers to the Use of BDA

Items	N	Mean	Std. Deviation
Lack of skilled personnel hinders our organization's ability to adopt BDA tools.	343	4.11	0.864
High implementation costs prevent us from investing in advanced analytics solutions.	343	4.11	0.865
Our existing IT infrastructure is not adequate to support BDA tools	343	4.1	0.813
Staff resistance to new technologies slows down BDA implementation in our warehouse operations	343	4.07	0.862
We have concerns about data privacy and security when using advanced analytics	343	4.1	0.78
There is uncertainty about the return on investment (ROI) for BDA adoption	343	4.13	0.821
Integration of BDA with our existing warehouse management systems is challenging.	343	4.15	0.792

Table 7 shows the descriptive statistics of the barriers that are perceived to hinder adoption of Big Data Analytics (BDA) in e-commerce warehousing. In general, the average scores on all the barriers show high levels, which means that the respondents consider there is a good agreement in what challenges are faced. The biggest inhibiter recorded was how BDA was to be integrated with other existing warehouse management systems with a mean value of 4.15 (SD = 0.792), and this indicates that technical compatibility is still a main area of concern. Uncertainty on return on investment (ROI) follows, with a mean of 4.13 (SD = 0.821), indicating difficulties of financial justification in using BDA tools. Skilled personnel shortage and large implementation costs had the same mean scores of 4.11, which revealed the argument that human resource capacity and instigation outlay is an important impediment. Besides, poor IT infrastructure (M = 4.10, SD = 0.813) and the issue of data privacy and security (M = 4.10, SD = 0.780) were identified as significant obstacles pointing to IT preparedness and strong data governance. Lastly, resistance to new technologies among staff members recorded the least mean (4.07), which albeit high, show that organisational culture and change management contribute to the challenge of adoption of BDA. This evidence highlights the fact that barriers related to technology, finance, and people contribute to limiting the application of BDA in e-commerce warehouses in the U.S.

Table 8: Enabling conditions on the adoption of Big Data Analytics (BDA)

ITEMS	N	Mean	Std. Deviation
Our top management actively supports the adoption of Big Data Analytics.	343	4.19	0.815
Our organization has sufficient financial resources to invest in BDA solutions	343	4.19	0.765
We have a strong IT infrastructure that supports advanced analytics applications	343	4.17	0.819
There is a clear strategic vision within our organization for BDA adoption.	343	4.13	0.83

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Our organizational culture encourages innovation and the use of new technologies	343	4.14	0.825
Employees receive training on how to use BDA tools effectively.	343	4.17	0.839

Table 8 portrays the descriptive statistics of perceived enabling conditions towards adoption of Big Data Analytics (BDA) in e-commerce warehousing. Generally, the mean scores of the items were high showing great consensus that the respondents feel that these are helping them to implement BDA. Top management support and financial resources were recorded to have the highest means of 4.19 (SD = 0.815 and 0.765 respectively). This underlines the paramount role of leadership commitment and sufficient funding as enablers of the successful BDA adoption and align with the literature that stresses the importance of strategic and financial support as the determinants of the technology implementation. Mean scores of 4.17 were also received in both strong IT infrastructure and employee training, which indicates that technical readiness and staff capability are also mandatory levels in enabling the proper use of BDA. Organisational culture, which promotes innovation, got an average of 4.14 (SD = 0.825) hence one of the important factors when adopting analytics is a culture that favours change in technology. Finally, the clear strategic vision of BDA adoption was ranked a bit lower (mean = 4.13 (SD = 0.830)), which is also high, which means that in terms of operation support, its planning could be improved further. These results overall suggest that leadership, funds, technical infrastructure, training and organisational culture as a combination may provide a conducive environment to BDA adoption in U.S. e-commerce warehousing.

As it can be seen in the findings, the barriers and enablers are rather essential in shaping the adoption of BDA within the SMEs of e-commerce warehousing in the U.S. The integration issues with the already existing warehouse management systems (M = 4.15) became the most significant barrier, which points at the technical compatibility, in line with Chouki et al. (2020) who mentioned integration and IT readiness as the primary factors obstructing adoption. Financial barriers are focused on such values as uncertainty about the ability to recover investment (M = 4.13) and great implementing costs (M = 4.11) which was supported by our results since Maroufkhani et al. (2023) mentioned that small budgets do not allow SMEs to implement advanced analytics. Unavailability of skilled staff (M = 4.11) and the poor IT infrastructure (M = 4.10) further proves the feeling about the shortage of human resource and IT power that impedes the BDA initiatives as stated by Tiwari and Khan (2020). On the other hand, top management support and financial resources (both M = 4.19) were found out as the main enablers, lending support to Dynamic Capabilities Theory (Teece, 2007), which focus on the role of reconfiguration of resources with leadership in making the successful adoption of technology. The availability of powerful IT infrastructure, worker training, and culture of innovation are additional indicators to support the notion that organisational preparedness is critical, similar in behaviour to El-Haddadeh et al. (2021). An added perception is on the high enabling qualities of training and culture, which implies that SMEs should place predominant focus on workforce construction and creativity in overcoming hurdles to BDA adoption. In general, the results indicate that strategic leadership, resources, and organisational culture were the determining factors of the BDA integration success contributing to theoretical propositions and more empirical literature.

CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

This study discussed the current level of Big Data Analytics (BDA) used in the inventory management processes by the U.S. e-commerce warehouses and its effects on outstanding major performance metrics, including stock turnover, length of work, stock accuracy, customer satisfaction, and stockout decrease. The results indicate that BDA-tools integration is linked with better inventory performance where the companies respond that they heavily depend on predictive analytics, real-time dashboards and advance analytics platforms. The study has also shown that generally big companies are the first to implement BDA, yet still small and medium-sized enterprises (SMEs) have significant obstacles which include integration, implementation cost, non-availability of qualified human resources as well as the insufficient level of return on investments. Nevertheless, important success factors such as the support of the top management, robust IT infrastructure, staff training, and the existence of organizational cultures friendly to innovations have been identified as the major enablers of successful BDA integration. Using the Resource-Based View and Dynamic Capabilities Theory as the theoretical lens, the research sets out to determine that BDA is a strategic ability delivering on agility, operational effectiveness, and competitiveness in dynamic market conditions as well as a technological tool. Thus, this study

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adds to theory and practice, providing knowledge about the process of changing the manner of work the warehouse has with the help of data-driven systems because of the changes in e-commerce these days.

This study although valuable has its share of limitations. First of all, the research is limited to Illinois and city of Chicago metropolitan area. In that geography is a top-level location in terms of logistics, results might not describe the overall landscape of the rest of the states or countries which have diverse e-commerce systems. Furthermore, incorporation of cross-sectional survey decreases the expansion of causality. Also, for SME emphasis, the study has led to important information to the research, but the incorporation of SMEs made sampling difficult and it is important to mention that the larger organizations that have well developed infrastructure would have yielded differing results. The survey was biased to medium-sized businesses so that it could not be generalized. Some other factors which include the macroeconomic conditions, industry specification, and technical maturity were not taken into extensive consideration as they could also affect inventory performance.

In accordance with the research results, SME firms are suggested to invest into employee training and capacity to overcome the lack of skilled workers and to provide the ability of the staff to operate BDA tools to improve inventory performance. Also, it is advisable that firms should invest in updating their IT structure in order to address the integration problems and getting the best of the analytics. Strong support should also be given by the top management through directions in terms of financial resources and establishment of an innovative culture. To overcome financial issues and ROI concerns, companies may introduce a small BDA project and show clerical benefits, which helps to justify the further spending. The incentives or subsidised training by the policymakers would be necessary to facilitate the adoption cost of SMEs, which would boost the national digital competitiveness. To academia, future studies are suggested to build on longitudinal researches and extend their analytical results to various industries and deduce the causal relationship of how BDA relates to inventory performance, therefore supplementing the theoretical applications of RBV and DCT. Generally, upgrading the skills of the workforce, the level of commitment to leadership, and sector research will be effective in the implementation of BDA and strategies of using e-commerce.

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