

Balancing Big Data Analytics and Privacy in Innovation: A Framework for Successful Product Development

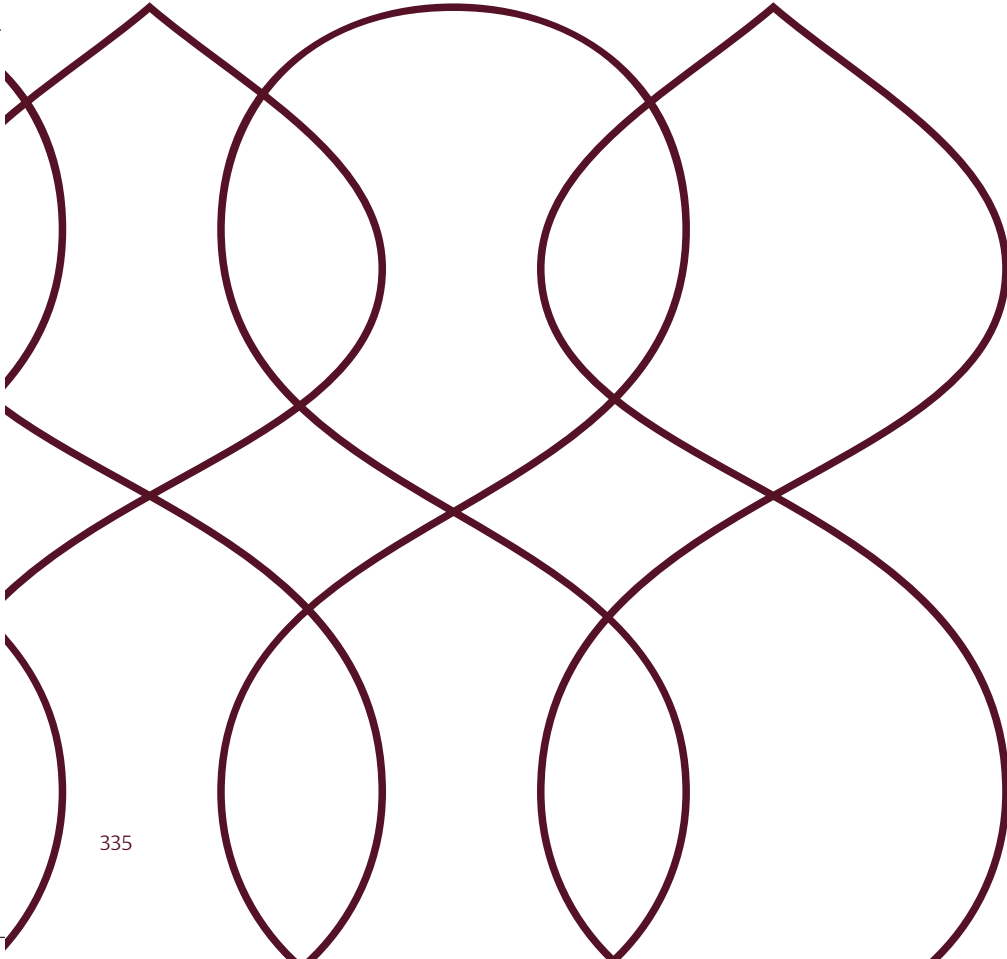
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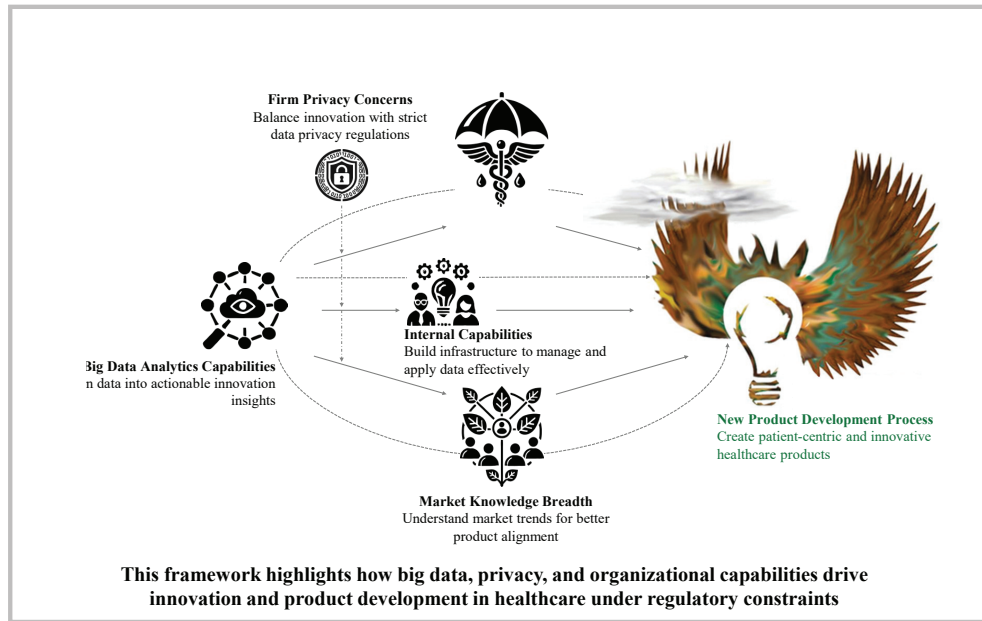
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Abstract :

This study explores how big data analytics capabilities enhance new product development in healthcare, emphasizing the critical role of service innovation in leveraging these capabilities to drive patient-centric solutions while managing privacy concerns. While big data analytics capabilities can drive medical innovation by providing insights into patient outcomes and disease trends, stringent regulations like GDPR create trade-offs between data-driven innovation and privacy. Using data from 324 healthcare sector professionals in the UK, this study examines how innovation capabilities, internal capabilities, and market knowledge breadth mediate the big data analytics capabilities-new product development relationship, with firm privacy concern moderating these effects. Findings reveal that big data analytics capabilities alone are insufficient for new product development; complementary capabilities are required to maximize their impact. Moreover, firm privacy concern significantly constrains the influence of big data analytics capabilities, underscoring the importance of privacy-compliant data practices. This study contributes to the resource-based view by highlighting big data analytics capabilities' dependence on other capabilities and offers actionable insights for healthcare managers navigating privacy and innovation demand.





Introduction

The market for global big data in the healthcare market is projected to grow from approximately USD 55.90 billion in 2024 to USD 137.40 billion by 2029, reflecting a compound annual growth rate (CAGR) of 19.71% during this period (mordorintelligence.com, 2024). Predictive analytics have demonstrated significant potential in reducing hospital readmissions. For example, organizations that have integrated predictive models into their readmission reduction workflows have achieved up to a 40% reduction in risk-adjusted readmission indices (healthcatalyst.com, 2024). However, the implementation of big data analytics in healthcare is accompanied by challenges, particularly concerning data privacy regulations. Legislations such as the General Data Protection Regulation (GDPR) in Europe and the Health Insurance Portability and Accountability Act (HIPAA) in the United States impose strict constraints on data collection, storage, and usage, necessitating robust compliance measures to protect patient information (straitresearch.com, 2024).

The healthcare sector presents a unique context for studying big data analytics capabilities, driven by the dual pressures of rapid innovation in patient-centric solutions and stringent data privacy regulations such as GDPR and HIPAA. Big data analytics capabilities play a crucial role in advancing medical products, technologies, and services



by leveraging large datasets to provide insights into patient outcomes, treatment efficacy, and disease trends. However, strict privacy regulations complicate their use, creating significant challenges for innovation (Lin & Kunnathur, 2019; Mikalef et al., 2019; Stremersch et al., 2023). Despite their recognized importance in driving new product development, there is a critical gap in understanding how these capabilities function effectively in highly regulated, privacy-sensitive contexts like healthcare.

Existing studies offer varied perspectives on the role and structure of big data analytics capabilities (Gupta & George, 2016; Lin & Kunnathur, 2019) but often overlook the mediating roles of innovation capabilities and internal capabilities in enabling big data analytics capabilities to effectively support new product development outcomes. While some research acknowledges big data analytics capabilities' potential in driving new product development, the indirect mechanisms—particularly through innovation capabilities, internal capabilities, and market knowledge breadth—remain underexplored, especially in privacy-sensitive sectors. Furthermore, the moderating role of firm privacy concern in contexts governed by stringent regulations, such as GDPR and HIPAA, has not been sufficiently investigated. Specifically, prior research has failed to examine how privacy-related restrictions influence the pathways through which big data analytics capabilities affect new product development or how firms can strategically align big data analytics capabilities with regulatory requirements.

This study addresses these critical gaps by investigating the impact of big data analytics capabilities on new product development in the healthcare sector. It emphasizes the importance of complementary organizational capabilities and strategic alignment with privacy regulations to manage the trade-offs between data-driven innovation and compliance obligations. The inclusion of innovation capabilities and internal capabilities as mediators is firmly grounded in the resource-based view and dynamic capabilities theory. According to the resource-based view, firms achieve competitive advantage by leveraging valuable resources (Barney, 1991). However, resources such as big data analytics capabilities are not inherently valuable unless supported by complementary capabilities that enable their effective utilization. Innovation capabilities represent a firm's ability to translate data-driven insights into novel products, processes, or services (Teece, 2007). These capabilities are crucial for realizing the potential of big data analytics capabilities to drive innovation outcomes like new product development. Internal capabilities reflect the firm's infrastructure, skilled workforce, and structured processes that facilitate the integration and management of big data resources (Akter et al., 2016). These capabilities provide the foundation for transforming complex data



into actionable insights, directly supporting innovation and operational excellence. In regulated industries like healthcare, these mediators play a particularly significant role. Here, innovation relies not only on leveraging data-driven insights but also on managing data securely, efficiently, and in compliance with privacy regulations. By integrating these mediators, this study extends the resource-based view to demonstrate how complementary capabilities maximize the impact of big data analytics capabilities on innovation outcomes under regulatory constraints.

This study systematically reviews the existing literature by categorizing prior research into four key themes: (i) big data analytics capabilities and new product development, (ii) the role of organizational capabilities, (iii) firm privacy concern in data-driven industries, and (iv) the healthcare context as a unique setting. This framework enables a focused exploration of the intersection of big data analytics, innovation, and regulatory compliance in healthcare, addressing critical gaps in the existing body of knowledge. By addressing these gaps, this study advances understanding of how big data analytics capabilities interact with organizational capabilities to drive new product development outcomes. It also introduces firm privacy concern as a novel moderating factor, providing new insights into how healthcare organizations balance the trade-offs between data-driven innovation and privacy compliance. Additionally, it investigates the moderating effect of firm privacy concern on these relationships. The research seeks to answer the following questions: (i) How do innovation capabilities, internal capabilities, and market knowledge breadth mediate the effect of big data analytics capabilities on the new product development process?, and (ii) To what extent does firm privacy concern moderate the impact of big data analytics capabilities on new product development through these mediating capabilities? To address these research questions, this study employs a quantitative approach, using a sample of employees and managers in the UK healthcare sector. Data collection involved a structured questionnaire based on validated scales, capturing responses from 324 participants. The analysis uses bootstrapping methods for hypothesis testing and confirmatory factor analysis to verify the reliability and validity of the constructs. Interaction effects were analyzed to assess the impact of the moderating role of firm privacy concern on big data analytics capabilities through the mediating capabilities, allowing a nuanced understanding of how privacy concerns influence the utilization of big data analytics capabilities in product development.

This study offers a comprehensive model to understand the impact of big data analytics capabilities on new product development, incorporating both mediating and moderating variables. It advances the resource-based view by demonstrating that big

data analytics capabilities require complementary capabilities—such as innovation capabilities, internal capabilities, and market knowledge breadth—to fully realize its potential in driving innovation outcomes. The study further highlights the critical role of firm privacy concern as a moderator in the big data analytics capabilities-new product development relationship, particularly in highly regulated environments like healthcare, where compliance with regulations limits data access and usage. This challenges the traditional understanding of resource complementarities and provides novel insights into the trade-offs associated with big data analytics capabilities. Specifically, while big data analytics capabilities enhance operational efficiency and data-driven decision-making, they may constrain broader exploratory learning, as seen in the negative relationship with market knowledge breadth. Finally, the study bridges the established resource-based view with emerging perspectives on data ethics and organizational agility, offering a nuanced framework for understanding data-driven innovation under regulatory and ethical constraints. By addressing these dynamics, the study equips managers with actionable strategies to balance data-driven innovation with privacy obligations, enabling them to navigate the complex trade-offs of today's digital business landscape.

Big Data Analytics Capabilities

Big data analytics capabilities refer to an organization's ability to effectively collect, process, and analyze large, complex datasets to generate actionable insights that support decision-making, innovation, and competitive advantage. These capabilities combine technological resources, human expertise, and organizational practices to transform data into strategic assets (Akter et al., 2016; Huynh et al., 2023; Jiang et al., 2024; Srinivasan and Swink, 2018). The application of big data analytics capabilities in healthcare is critical, given the sector's reliance on data to innovate in patient care and operational efficiency. For example, predictive analytics have been shown to reduce hospital readmissions by up to 40% through the early identification of high-risk patients (HealthCatalyst, 2023). However, healthcare organizations must balance this potential with firm privacy concern, making the healthcare context both uniquely challenging and essential for study. Big data analytics capabilities enable firms to gather, analyze, and interpret vast amounts of data related to market trends, customer preferences, and competitor activities. In healthcare, big data analytics capabilities facilitate enhanced patient outcomes, operational efficiencies, and treatment innovations by enabling the analysis of large-scale patient data, medical records, and treatment protocols, thus supporting more effective and personalized healthcare solutions. By effectively utilizing big data, firms can inform strategic decision-making, drive innovation, and improve the new product development processes (Mikalef et al., 2019). A firm is considered to have high big data analytics capabilities when it effectively utilizes big data to achieve strategic objectives by integrating data insights across various functions (Mikalef et al., 2019).

While scholars (e.g., Gupta & George, 2016; Mikalef et al., 2018; 2019) have provided foundational insights into big data analytics capabilities and innovation, they have not addressed privacy-sensitive contexts such as healthcare, where stringent regulations like GDPR significantly constrain data usage. This study extends their work by investigating the critical moderating role of firm privacy concern and exploring the mediating roles of innovation capabilities, internal capabilities, and market knowledge breadth in the big data analytics-new product development relationship within healthcare. Scholars categorize big data analytics capabilities in different ways, focusing on aspects such as tangible resources, intangible capabilities, and human skills (Gupta & George, 2016; Mikalef et al., 2019). This variation highlights the challenges of capturing the full scope of big data analytics capabilities, as each approach offers unique perspectives on how firms deploy and benefit from big data resources.



The development of measures for assessing big data analytics capabilities typically involves item generation, pre-pilot studies, and pilot studies, ensuring alignment with both theoretical constructs and practical applications (Lin & Kunnathur, 2019). Tangible capabilities, such as data storage and processing tools, allow firms to manage and analyze large datasets. For example, centralized data warehouses that integrate internal and external data sources enable high-value analyses, improving the responsiveness to market trends (Ferraris et al., 2019; Wamba et al., 2017). In healthcare, such integration can enhance real-time decision-making in treatment planning and response to disease outbreaks. Intangible capabilities, like a data-driven culture, are equally vital, as they foster organizational behaviors that prioritize data over intuition in decision-making (Ciampi et al., 2021). Research shows that firms with strong data-oriented cultures are more likely to leverage big data analytics capabilities for sustained innovation, as they continuously adapt and refine business processes based on data insights (e.g., Mikalef et al., 2018).

The resource-based view provides a theoretical framework for big data analytics capabilities, arguing that competitive advantage arises from resources that are valuable, rare, and difficult to imitate (Barney, 1991; Bharadwaj, 2000). Big data analytics capabilities exemplify these characteristics by combining data, technology, and human skills in unique ways that competitors cannot easily replicate (Wamba et al., 2017). Through big data analytics capabilities, firms can enhance the breadth of their market knowledge by providing comprehensive insights into market trends, consumer needs, and competitor actions (Jaworski & Kohli, 1993). In healthcare, this capability enables deeper insights into patient needs and treatment patterns, thereby aiding in the creation of patient-centric products and services. With high big data analytics capabilities, companies can analyze large datasets to detect patterns and forecast trends, thus creating products that better meet customer expectations (Ferraris et al., 2019). Big data analytics capabilities also support rapid iteration and feedback in new product development. Firms using big data analytics capabilities can perform real-time data analysis, refining products based on evolving market demands and customer feedback, which is particularly valuable in fast-paced industries (Mikalef et al., 2019). For instance, Amazon uses big data analytics capabilities to continuously analyze customer behavior, allowing it to adjust product offerings and optimize supply chains in response to demand.

Additionally, big data analytics capabilities strengthen internal capabilities by enhancing the data management infrastructure, which supports streamlined workflows and cross-functional integration. Effective internal capabilities are essential for deploying the



insights offered by big data analytics capabilities across the organization, facilitating data accessibility and alignment with strategic objectives (Sivarajah et al., 2022). In healthcare, internal capabilities enable more efficient data handling, ensuring that patient information is available in a secure and accessible way across departments for better service integration. Firms with robust internal systems are better positioned to leverage real-time analytics for product adjustments, thereby improving responsiveness in new product development (Gandomi & Haider, 2015). Big data analytics capabilities also enhance innovation capabilities, enabling firms to creatively apply data insights to develop new products and services. By fostering a culture of experimentation, big data analytics capabilities encourage data-driven innovation, transforming insights into competitive offerings (Subramaniam & Youndt, 2005; Calantone, Cavusgil, & Zhao, 2002). However, Mikalef et al. (2019) warn that an over-reliance on data can lead to “innovation inertia,” where firms become too focused on past data trends, limiting radical innovation. To avoid this, firms must balance data-driven insights with broader innovation goals.

While big data analytics capabilities offer significant potential for new product development, the growing emphasis on data privacy introduces challenges, particularly in the healthcare industry, where privacy and ethical standards are high. Firm privacy concern, reflecting a company's commitment to data protection and regulatory compliance, can moderate big data analytics capabilities' effectiveness in new product development. High privacy concerns may limit data collection and access, restricting the depth of insights available for product development. Regulatory frameworks like GDPR require firms to be selective in their data practices, limiting data usage to ensure compliance (Acciarini et al., 2023). Privacy concerns can also serve as a market differentiator. Firms committed to data protection can foster customer trust, increasing willingness to share data within permissible boundaries (Martin, Borah, & Palmatier, 2017). For example, Apple's focus on privacy distinguishes it from competitors, aligning its new product development process with its brand values and enhancing consumer trust. By prioritizing on-device data processing over centralized analysis and minimizing data collection, Apple has bolstered its reputation as a privacy-conscious company. However, this approach also constrains its ability to gather deep consumer insights, potentially limiting innovation in areas like personalized services and new product features. In contrast, firms like Google, which adopt a more liberal approach to data utilization, benefit from greater data-driven innovation. This dynamic becomes even more pronounced in regulated sectors such as healthcare and finance, where stringent privacy restrictions further challenge data-driven advancements (Quach et al., 2022).



Big data analytics capabilities serve as foundational resources, enabling firms to process large datasets and generate actionable insights for strategic decision-making and innovation. Grounded in the resource-based view, big data analytics capabilities are positioned as an antecedent to new product development outcomes, as they facilitate the development of higher-order capabilities, including innovation capabilities, internal capabilities, and market knowledge breadth (Gupta & George, 2016; Teece, 2007). By supporting real-time data analysis and aligning strategic goals with operational processes, big data analytics capabilities enable organizations to navigate dynamic markets and sustain competitive advantage. However, the full potential of big data analytics capabilities depends on balancing the data infrastructure with privacy considerations, especially in healthcare, where ethical and regulatory demands are stringent. As recent studies emphasize (Chang et al., 2023; Mikalef et al., 2019), the impact of big data analytics capabilities relies on a supportive ecosystem that fosters data management and adaptive insights, enabling firms to navigate today's complex market landscape effectively.

As firms increasingly rely on big data analytics capabilities to drive innovation, the importance of balancing data-driven insights with consumer privacy considerations has come to the forefront (Gupta & George, 2016; Martin et al., 2017). In healthcare, big data analytics capabilities can significantly enhance patient care and operational efficiencies, allowing firms to analyze vast datasets from patient records, treatment outcomes, and medical trends to create targeted, innovative products that meet critical health needs. However, with the growing regulatory and consumer demands for data privacy, particularly stringent in healthcare due to ethical and legal considerations, organizations are facing heightened pressures to safeguard personal information and adopt restrictive data practices. The issue of firm privacy concerns—defined as the organizational emphasis on safeguarding customer data and adhering to privacy regulations—has emerged as a critical factor influencing the relationship between big data analytics capabilities and new product development. Privacy concerns impose constraints on data usage and availability, thereby moderating the extent to which big data analytics can be leveraged effectively in the innovation process (Pavlou, 2011). Indeed, high privacy concerns can limit the scope of data analysis and reduce the insights available to the firm, potentially weakening the ability of big data analytics capabilities to contribute to new product development outcomes, especially in highly regulated fields like healthcare.

The indirect effect of big data analytics capabilities on new product development is typically mediated by three key organizational capabilities: innovation capabilities,



internal capabilities, and market knowledge breadth. Innovation capabilities enable firms to creatively leverage data insights and transform resources, such as big data analytics capabilities, into novel products or services that meet emerging consumer demands (Calantone, Cavusgil, & Zhao, 2002; Barney, 1991). Grounded in the resource-based view, these capabilities are critical for utilizing valuable and rare resources. Additionally, dynamic capabilities theory underscores how firms adapt to market changes by integrating and reconfiguring their data-driven resources into actionable outcomes (Teece, 2007). In healthcare, these capabilities are essential for translating data insights into innovations in patient care and new treatments. However, when firm privacy concern is high, the restrictions placed on data collection and processing can limit the range of insights available for innovation. This constraint demonstrates how high privacy concerns can inhibit the potential of innovation capabilities to fully leverage big data analytics capabilities for new product development, as firms must navigate privacy regulations that restrict the data accessible for product ideation and development (Srinivasan & Swink, 2018).

Similarly, internal capabilities and market knowledge breadth play critical roles in translating big data analytics capabilities into new product development outcomes, yet both are moderated by firm privacy concern. Internal capabilities, including infrastructure, data management skills, and cross-functional processes, are essential for effective data handling and integration within the organization (Wamba et al., 2017; Akter et al., 2016). In healthcare, where data must often be shared securely across departments for continuity of care, privacy concerns can limit big data analytics capabilities' ability to streamline these internal processes, fragmenting data flows and thereby restricting product development insights. Market knowledge breadth, or the firm's comprehensive understanding of market dynamics, is also restricted by high privacy concerns, as firms may limit the data-sharing practices that are essential for a cohesive market perspective (Jaworski & Kohli, 1993). For instance, firms in the healthcare and finance sectors face rigorous privacy regulations that constrain the types and depth of consumer data available, reducing the insights that market knowledge breadth can contribute to new product development (Anderson & Agarwal, 2011). As a result, firm privacy concern moderates the indirect effects of big data analytics capabilities on new product development through these organizational capabilities, restricting the extent to which big data analytics capabilities can drive effective, data-informed product development. Firm privacy concerns also moderate the indirect effects of big data analytics capabilities on new product development by limiting the extent to which these capabilities can drive effective, data-informed innovation. The



new product development process is a structured framework encompassing stages from idea generation to commercialization. It integrates cross-functional collaboration to conceptualize, design, and deliver products or services that align with customer needs, address market opportunities, and achieve organizational objectives (Atuahene-Gima and Ko, 2001; Borah et al., 2023; Bouschery et al., 2023; Moorman, 1995; Sahi et al., 2023). In healthcare, this limitation is particularly impactful, as it can hinder the integration of comprehensive health data required for the development of patient-centric products and treatments.

While big data analytics capabilities are widely acknowledged for their transformative potential in new product development, their impact is not automatic. Research consistently shows that big data analytics capabilities' value depends largely on a firm's complementary internal mechanisms that can effectively interpret, integrate, and apply data insights (Gupta & George, 2016; Kiron et al., 2014). Without these foundational elements, investments in big data analytics capabilities are often squandered, as raw data lacks the necessary context and agility to drive innovation. This relationship highlights the critical importance of three mediating factors—innovation capabilities, internal capabilities, and market knowledge breadth—in enabling firms to harness big data analytics capabilities for impactful new product development outcomes.

Innovation capabilities encompass an organization's ability to leverage knowledge, skills, and structured procedures to engage in technical, non-technical, marketing, and service innovations (Behl et al., 2023; Foroudi et al., 2016; Wang & Zhang, 2024). For example, the use of knowledge and skills to develop technical innovations highlights the importance of human capital, while structured procedures for marketing and service innovations reflect the role of organizational processes in fostering creativity and value creation. These capabilities enable firms to adapt to dynamic markets and maintain competitive advantage by integrating technological resources and external knowledge. Innovation capabilities are the lynchpin that allows organizations to translate big data insights into new, market-driven products, embodying the creative flexibility needed to reframe data into novel solutions (Calantone, Cavusgil, & Zhao, 2002). In healthcare, innovation capabilities are particularly vital, as they allow organizations to transform big data analytics insights into patient-centric solutions, improve clinical outcomes, and reduce costs. This is especially critical as firms increasingly face shortened product life cycles and heightened market competition, requiring agile responses to emerging trends (Subramaniam & Youndt, 2005). As a predominantly service-oriented sector, healthcare provides fertile ground for the application of service innovation concepts.



Unlike product innovation, service innovation focuses on intangibility, co-creation of value, and customization, aligning closely with the patient-centric nature of healthcare (Ostrom et al., 2010). Leveraging big data analytics, healthcare providers can enhance service innovation by offering personalized care, predictive diagnostics, and real-time patient support systems, thereby improving both operational and clinical outcomes. Dynamic capabilities, such as adaptability and customer engagement, play a critical role in translating data-driven insights into innovative service solutions (Lusch & Nambisan, 2015). These advancements underscore the importance of aligning innovation capabilities with service delivery processes to co-create value with patients and stakeholders.

For instance, Amazon's predictive analytics not only leverages customer data but actively fuels product innovation through dynamic, data-informed adjustments in real-time, helping the company remain agile and competitive (Davenport, 2013; Chen, Chiang, & Storey, 2012). Without innovation capabilities, big data analytics capabilities' investments risk stagnation, as firms lack the interpretive agility to transform insights into actionable and differentiated new product development pathways (Kim et al., 2011). This demonstrates that big data analytics capabilities alone are insufficient; rather, it is the innovation capability that ensures data insights translate into strategically valuable products (O'Reilly & Tushman, 2008).

Internal capabilities—encompassing IT infrastructure, analytical skills, and structured processes—are essential for translating big data analytics capabilities into sustained new product development success (Wamba et al., 2017; Akter et al., 2016). This is especially relevant in healthcare, where robust internal systems support secure, compliant handling of sensitive health data and facilitate its integration into clinical and product innovations. Lacking these competencies, firms face significant limitations in extracting actionable insights from data, as data without structure or skilled analysis lacks direction and operational value (Ross et al., 2013). IBM, for example, illustrates the power of strong internal data management, as it uses its big data analytics capabilities infrastructure to make precise, data-driven decisions across functions, optimizing its entire value chain from ideation to product launch (Grover et al., 2018). According to Ghasemaghahi, Hassanein, & Turel (2017), firms with developed internal analytics capabilities can transform data insights into strategic assets, enabling them to adapt to shifting market conditions and optimize product outcomes. The absence of these capabilities often leads to underutilized big data analytics capabilities investments, emphasizing that data analytics alone does not drive innovation; rather, it is the sophisticated deployment and structured internal capability that converts data into effective new product development



outputs (Vidgen et al., 2017).

Market knowledge breadth—the scope and diversity of market intelligence embedded across the firm—further amplifies the value of big data analytics capabilities, enabling a comprehensive understanding of consumer and competitive landscapes (Day, 1994; Kohli & Jaworski, 1990). In healthcare, where understanding market dynamics involves tracking complex patient needs and industry regulations, broad market knowledge supports targeted, compliant innovations. With effective knowledge integration mechanisms, firms can distribute insights from big data analytics capabilities across functional boundaries, ensuring data informs and unifies new product development efforts (Jaworski & Kohli, 1993). For instance, Procter & Gamble's "Connect + Develop" program exemplifies how broad market knowledge enables firms to capture and leverage external insights, aligning new product development with consumer trends and creating a robust, market-aligned innovation pipeline (Huston & Sakkab, 2006). In the absence of such mechanisms, insights from big data analytics capabilities often remain isolated within functional silos, hindering their relevance to cross-functional teams and limiting their impact on new product development (De Luca & Atuahene-Gima, 2007). This is particularly pertinent in cultural contexts with low inter-departmental communication norms, such as East Asian firms, where knowledge sharing may be limited due to collectivist values (Chow et al., 1999). Knowledge integration mechanisms can mitigate these barriers, facilitating a unified approach to new product development that is informed by a rich, organization-wide understanding of market conditions (Li & Atuahene-Gima, 2001; Yasmin et al., 2020).

The effect of big data analytics capabilities on new product development is significantly mediated by innovation capabilities, internal capabilities, and market knowledge breadth. Firms that strengthen these mediators can transform big data analytics capabilities investments into strategically aligned, innovative products, ensuring that data-driven insights enhance product competitiveness and relevance (Manyika et al., 2011; Zahra & George, 2002; Cohen & Levinthal, 1990). This framework positions big data analytics capabilities not merely as an analytical asset but as part of a broader innovation ecosystem that drives sustainable competitive advantage through integrated, data-enabled product development, particularly essential in highly regulated fields like healthcare, where compliance and patient-centricity drive new product development.



Hypothesis 1: (a) innovation capabilities, (b) internal capabilities, and (c) market knowledge breadth positively mediate the relationship between big data analytics capabilities and the new product development process

In the contemporary data-driven business landscape, big data analytics capabilities have emerged as a transformative tool for enhancing new product development by providing firms with comprehensive insights into consumer behavior, market trends, and competitive dynamics (Gupta & George, 2016; Chen et al., 2012). However, as firms increasingly rely on data to drive innovation, they must also address growing privacy concerns from consumers and regulators. This is especially crucial in healthcare, where patient privacy is governed by strict regulatory frameworks. The term 'firm privacy concern' refers to an organization's sensitivity to privacy issues, encompassing both internal policies aimed at protecting consumer and patient data and adherence to external regulatory requirements (Culnan & Williams, 2009; Martin et al., 2017). Firm privacy concern is conceptualized as the degree to which an organization is sensitive to privacy-related risks, prioritizes data protection, and complies with regulatory frameworks (Bélanger & Crossler, 2011; Culnan & Williams, 2009; Smith et al., 2011) such as GDPR and HIPAA. It encompasses organizational policies, strategies, and practices aimed at safeguarding customer data while adhering to legal requirements. The term 'big data analytics capabilities' refers to a firm's ability to effectively collect, manage, and analyze large datasets to generate actionable insights that support strategic decision-making and innovation. This includes technological infrastructure, human skills, and organizational culture (Gupta & George, 2016).

Market knowledge breadth refers to the diversity and comprehensiveness of an organization's understanding of its external environment, including customer preferences, competitor strategies, industry trends, and market dynamics (Ozdemir et al., 2024; Wang et al., 2024; Ye et al., 2024). This capability enables firms to acquire and integrate information from various market-related sources, supporting strategic decision-making, fostering innovation, and facilitating more informed and adaptive product development (Day, 1994; Kohli & Jaworski, 1990).

High levels of privacy concerns create operational constraints that limit a firm's ability to fully exploit big data analytics capabilities. These concerns restrict the types and depth of data that can be collected, shared, and integrated, thereby hindering the potential of big data analytics in processes such as new product development (Acquisti et al., 2016). In healthcare, where data often includes highly sensitive personal health



information, firms face added responsibilities and restrictions that may limit data access and processing capabilities, thereby impacting the scope of data-driven innovations. The impact of big data analytics capabilities on new product development is not a direct, linear relationship; rather, it is moderated by a firm's approach to privacy. When privacy concerns are high, firms may restrict data access, limit the integration of insights across functional units, and impose additional compliance costs, all of which can dilute big data analytics capabilities' potential for driving new product development (Pavlou, 2011; Xu et al., 2012). Privacy-conscious firms in healthcare, for example, may need to balance the competitive advantage offered by data analytics with the ethical and legal obligations associated with patient data protection, which can, in turn, impact their ability to innovate. Therefore, we propose that firm privacy concern moderates the relationship between big data analytics capabilities and new product development, potentially diminishing the positive effects of big data analytics capabilities on new product development outcomes, particularly in highly regulated sectors like healthcare. Organizations in these fields must navigate complex trade-offs between leveraging data for product innovation and adhering to stringent privacy requirements that safeguard patient rights.

The term 'innovation capabilities' refers to a firm's ability to translate data-derived insights into novel, market-responsive products. These capabilities enable firms to harness big data analytics capabilities to ideate, develop, and launch new products effectively (Subramaniam & Youndt, 2005). However, high firm privacy concern may impose constraints on these capabilities by limiting the types of data that can be used for innovation purposes. Privacy-conscious firms may have to anonymize or aggregate data, reducing the specificity and granularity of insights available for innovation (Srinivasan & Swink, 2018). In regulated sectors such as healthcare and finance, where privacy restrictions are stringent, this dynamic is even more pronounced. In healthcare, for example, firms in the healthcare sector often face stringent limitations on accessing sensitive patient data due to regulations like the HIPAA in the United States. These laws require the implementation of elaborate privacy protocols to protect patient information. While essential for safeguarding sensitive data, such regulations can significantly restrict the internal processing of detailed health metrics, which are vital for driving innovation in personalized healthcare solutions. The need for anonymization or aggregated data in healthcare often limits the granularity needed for deep insights, affecting the potential of big data analytics capabilities to inform novel healthcare products. As such, we



hypothesize that firm privacy concern moderates, via innovation capabilities, the indirect effect of big data analytics capabilities on new product development, with high privacy concerns limiting the extent to which firms can utilize big data analytics capabilities to generate innovation-driven product development. The resource-based view highlights the role of complementary resources, such as data accessibility, in leveraging big data analytics capabilities (Barney, 1991). However, dynamic capabilities theory emphasizes how firms must navigate external constraints, such as regulatory privacy concerns, to maintain flexibility and adapt resources effectively (Teece, 2007). Firm privacy concern may inhibit the transformation of big data insights into innovation due to restricted data usage. Thus, we hypothesize:



Hypothesis 2a: Firm privacy concern attenuates the relationship between big data analytics capabilities and innovation capabilities

Internal capabilities are the organization's internal resources, processes, and competencies that enable the efficient coordination, integration, and utilization of assets to achieve strategic objectives (Germann et al., 2013; Grego et al., 2024; Sjödin et al., 2024). These capabilities support operational excellence and foster innovation by aligning resources with organizational goals and creating a foundation for adaptability in dynamic environments. Internal capabilities are the structural and technical resources, including infrastructure, data processing skills, and organizational processes, that enable big data analytics capabilities to influence new product development. These capabilities allow firms to manage, analyze, and deploy data insights systematically, aligning data utilization with organizational goals (Wamba et al., 2017; Akter et al., 2016). However, high levels of firm privacy concern may undermine the effectiveness of these internal capabilities by imposing data access restrictions and limiting the integration of big data analytics capabilities into internal processes (Smith, Dinev, & Xu, 2011). For example, Facebook's Cambridge Analytica scandal brought significant scrutiny to its data handling practices, resulting in stringent privacy reforms and restricted data-sharing capabilities (Isaak & Hanna, 2018). These changes, while essential for restoring consumer trust, limited Facebook's access to granular user data, subsequently affecting its internal capabilities for driving data-informed product innovation and personalization.

Similar dynamics are evident in sectors such as healthcare, where firms must navigate complex data privacy regulations that rigorously restrict data use and access. Healthcare firms, therefore, often face restrictions that impact their internal capabilities to fully leverage insights into big data analytics capabilities, particularly in areas like personalized treatment plans and precision medicine development, where detailed patient data is essential. Similarly, in the finance industry, firms facing high regulatory scrutiny on data usage must also adopt complex privacy protocols, often limiting data accessibility for internal use (Gandomi & Haider, 2015). These privacy-driven restrictions reduce the flexibility and scalability of internal capabilities, preventing firms from fully exploiting big data analytics capabilities for product development. Thus, we hypothesize that firm privacy concern moderates, via internal capabilities, the indirect effect of big data analytics capabilities on new product development, as heightened privacy concerns necessitate restrictive data practices that reduce the effectiveness of internal capabilities in supporting data-driven product development.



Hypothesis 2b: Firm privacy concern attenuates the relationship between big data analytics capabilities and internal capabilities.

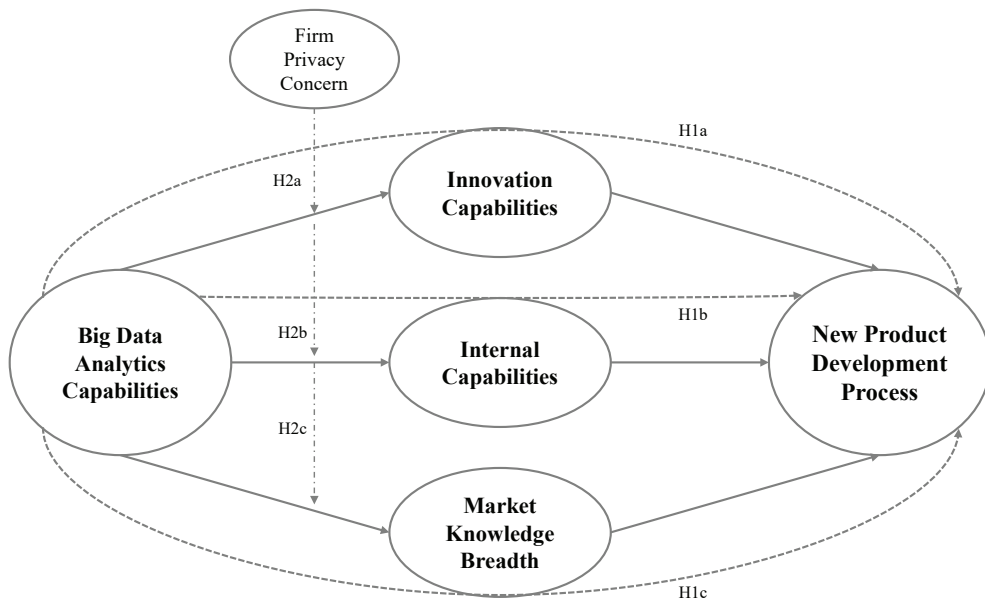
Market knowledge breadth captures the diversity and comprehensiveness of a firm's understanding of consumer needs, competitor actions, and industry trends (Day, 1994; Jaworski & Kohli, 1993). Big data analytics capabilities enhance market knowledge breadth by providing firms with detailed insights into emerging market trends and shifting consumer preferences, informing new product development decisions. However, when firm privacy concern is high, firms may face limitations on data sharing and cross-functional data integration, which restricts the diversity and scope of market insights available for new product development (Li & Atuahene-Gima, 2001; Pavlou, 2011). For example, the GDPR in the European Union imposes strict guidelines on how firms collect, process, and share personal data. Under GDPR, companies must minimize data processing to what is necessary for specific purposes, impacting the availability and flow of information across business functions (de Hert et al., 2018). In the healthcare sector, these privacy concerns are particularly impactful. Pharmaceutical companies, which are subject to stringent data privacy regulations, often face significant challenges in accessing and utilizing patient data to gain insights into health trends and consumer demands due to restrictions on data sharing (Anderson & Agarwal, 2011). This limited access to comprehensive patient data constrains the Market Knowledge Breadth that healthcare firms need to develop targeted, innovative products that address patient needs effectively. The inability to fully integrate patient insights across functions can hinder their responsiveness to shifts in healthcare demands, such as emerging health conditions or consumer preferences for personalized treatment options.

Such limitations narrow market knowledge breadth, preventing firms from gaining a comprehensive view of market demands, which in turn affects their ability to create competitive, data-driven products. In light of these constraints, we hypothesize that firm privacy concern moderates, via market knowledge breadth, the indirect effect of big data analytics capabilities on new product development. High privacy concerns restrict the breadth and diversity of market insights accessible to firms, weakening the positive impact of big data analytics capabilities on new product development by limiting the market knowledge that can inform product development.

Hypothesis 2c: Firm privacy concern attenuates the relationship between big data analytics capabilities and market knowledge breadth

Based on the above, firm privacy concern plays a crucial moderating role in the relationship between big data analytics capabilities and new product development, influencing the pathways through innovation capabilities, internal capabilities, and market knowledge breadth. These constraints are particularly significant in highly regulated industries, such as healthcare, where stringent data privacy laws restrict the use of patient information. In healthcare, privacy compliance obligations like the HIPAA in the United States and the GDPR in the European Union make it challenging for firms to leverage comprehensive patient data, thereby affecting their market knowledge breadth and ability to develop personalized, data-informed health solutions. These constraints highlight the complex trade-offs between privacy compliance and data-driven innovation, as firms must navigate a regulatory landscape that increasingly prioritizes data protection (Culnan & Williams, 2009; Pavlou, 2011). Consequently, firms with high privacy concerns may face reduced competitive advantages in new product development, underscoring the importance of the strategic management of privacy concerns to maximize the utility of big data analytics capabilities in a way that balances regulatory obligations with innovation goals.

Figure 1: The study's conceptual model



Methods

We employed a purposive sampling method to ensure that participants had direct experience and knowledge relevant to the study's focus on big data analytics capabilities and innovation processes. This approach allowed us to target key informants who were well-positioned to provide insights into organizational capabilities and decision-making processes. The data collection process was carefully designed to test the study's hypotheses within a sample of healthcare industry employees and managers in the UK. Initially, convenience sampling was employed, as described by McDaniel and Gates (2006), to recruit participants, followed by snowball sampling to expand the sample size and enhance representativeness (Goodman, 1961). The final sample included respondents from diverse roles, such as managers and employees, to capture a holistic view of the phenomena under investigation. Data was gathered over two months, from September to October 2024, through printed questionnaires, with 324 complete responses out of the 550 distributed to employees and managers. The survey focused on examining the effects of big data analytics capabilities, innovation capabilities, internal capabilities, market knowledge breadth, and the new product development process.

To address potential biases, several measures were implemented. Diversity across organizational sizes and roles was ensured to reduce selection bias, and participants were assured of the strict confidentiality of their responses, encouraging a broad range of perspectives (Sekaran, 2003). To assess non-response bias, a time-trend extrapolation test was conducted (Armstrong & Overton, 1977), which revealed no significant differences between early and late respondents. Additionally, a Mann-Whitney U-test compared the responses of the first 50 participants with the last 50 (Lambert & Harrington, 1990), with results indicating no significant differences in response patterns. These findings suggest that non-response bias is unlikely to have influenced the results. Table 1 provides a detailed summary of the sample characteristics, revealing a higher proportion of female respondents (57.7%), a younger age profile with 59.6% under 25, and a majority holding postgraduate qualifications (53.4%). Middle management was the most common role (32.7%). The study employed a stratified random sampling method to ensure representation across key sectors, including healthcare, manufacturing, and technology. In total, 350 responses were collected, with 320 valid responses used for analysis. The sample included 40% senior managers, 35% mid-level managers, and 25% technical specialists, with firms ranging in size from small enterprises (20%) to large corporations (40%). This predominantly young, educated, and diverse sample provides valuable insights, particularly in the healthcare context.

<<Please Insert Table 1 Here>>

This study utilized measurement scales drawn from previously established and validated research instruments, following previous scholars (Hair et al., 2010; Kline, 2015) recommendation to ensure psychometric reliability and accuracy. Participants provided their responses on a seven-point Likert scale, with values ranging from 1 ("strongly disagree") to 7 ("strongly agree"). The survey was organized into distinct sections, beginning with questions to capture demographic and background information. It included seven items focused on big data analytics capabilities (Akter et al., 2016; Srinivasan & Swink, 2018), innovation capabilities (Foroudi et al., 2016), internal capabilities (Germann et al., 2013), market knowledge breadth (Ozdemir et al., 2024), the new product development processes (Atuahene-Gima & Ko, 2001; Moorman, 1995), and firm privacy concern (Saarikko et al., 2020). For a detailed list of the specific items used, see Table 2.

<<<Please Insert Table 2 Here>>>

Analysis and Findings

Evaluation of Measurement Tools

To verify the reliability and validity of the measures, we adhered strictly to established guidelines. The Cronbach's alpha values, which indicate the internal consistency of the scales used, ranged from .919 to .960, as presented in Table 2, indicating strong reliability. Additionally, we examined the average variance extracted (AVE) for each construct, ensuring each met or surpassed the .50 threshold recommended by Fornell and Larcker (1981), which confirmed the constructs' reliability and validity. Confirmatory factor analysis (CFA) was conducted using Amos to assess the constructs, as it is known for providing reliable, unbiased estimates for both multivariate normal and non-normal data. The analysis indicated a strong model fit, with significant factor loadings that supported the scales' convergent validity. Table 3 presents the validity, reliability, and correlation matrix for the constructs used in the study. The constructs demonstrate strong reliability, with composite reliability (CR) values exceeding 0.7 and AVE values above 0.5, indicating convergent validity. Discriminant validity is confirmed, as the maximum shared variance is lower than the AVE for all constructs. Model fit indices indicate an excellent fit (CFI=.982, TLI=.978; RMSEA=.056).

To address potential common method bias (CMB), we used Harman's one-factor test alongside a common latent factor approach. This analysis involved comparing the chi-square values of the original model with a model restricted by a common factor, based on procedures established by Lindell and Whitney (2001), Podsakoff et al. (2003), MacKenzie and Podsakoff (2012), and Malhotra, Kim, and Patil (2006). The results showed a significant difference between the models with low shared variance, indicating minimal influence of method biases. Steps were taken to improve question clarity and maintain confidentiality, and the survey included both positively and negatively phrased items to further reduce bias. Additionally, we applied the correlation-based marker variable approach recommended by Lindell and Whitney (2001), selecting a marker variable expected to be unrelated to the main constructs, and found minimal shared variance. After adjusting for CMB and comparing the revised measurement model to the original, no notable decrease in model fit was observed ($p < .05$), confirming that CMB did not significantly impact the study's findings.

<<<Please Insert Table 3>>>

Hypotheses Examination

We tested the hypotheses using the PROCESS macro developed by Hayes (2013), employing a bootstrapping approach with 5,000 resamples to generate bias-corrected confidence intervals. Bootstrapping was selected due to its suitability for complex models and its ability to provide robust estimates of direct, indirect, and conditional effects. Unlike traditional statistical techniques, bootstrapping does not assume the normality of sampling distributions, thus making it particularly appropriate for our dataset, where non-linear relationships and interaction terms may challenge normality assumptions. To validate the robustness of our proposed framework, we tested several alternative models alongside the main effects model. First, we examined a direct effect model to assess the relationship between big data analytics capabilities and new product development without mediators. Second, we explored alternative mediators by substituting innovation capabilities, internal capabilities, and market knowledge breadth with constructs such as organizational agility to evaluate their explanatory power. Third, we considered alternative moderators by replacing firm privacy concern with environmental uncertainty to examine its unique contribution.



The results demonstrated that the proposed model—positioning big data analytics capabilities as an antecedent mediated by complementary capabilities (innovation capabilities, internal capabilities, and market knowledge breadth) and moderated by firm privacy concern—provides the strongest explanatory power. This confirms the importance of the mediating and moderating pathways in understanding the impact of big data analytics capabilities on new product development outcomes. The bootstrapping approach offered several advantages in this study. First, it is particularly well-suited for models involving mediation and moderation effects, as it provides accurate and reliable estimates of effect sizes and statistical significance. Second, bootstrapping generates bias-corrected and accelerated confidence intervals, ensuring greater precision when testing indirect and interaction effects (Preacher & Hayes, 2008). Finally, the step-by-step hypothesis testing facilitated by PROCESS improves transparency and interpretability, allowing us to identify and isolate significant mediation and moderation pathways more effectively than methods such as structural equation modeling, which estimates all relationships simultaneously. Given the complexity of our conceptual model and the study's objectives, the use of bootstrapping within PROCESS provided a rigorous and reliable statistical approach for evaluating both direct and indirect effects of big data analytics capabilities on new product development outcomes. This method allowed us to generate robust findings while accommodating the nuanced relationships examined in the study.

To evaluate the main effects model, regression analysis was performed in SPSS. This bootstrapping approach offers the benefit of not relying on the specific distributional assumptions required for inferential statistics, as noted by Preacher et al. (2007) (see Table 4). The analysis revealed several significant relationships within the model. Big data analytics capabilities had a strong positive effect on innovation capabilities ($b = 0.8676$, $t = 50.4962$, $p < 0.001$), indicating that higher levels of big data analytics capabilities are associated with enhanced innovation within organizations. Alternative model testing confirmed the robustness of the proposed framework. The direct effect model demonstrated weaker relationships, underscoring the importance of mediators. Similarly, substituting mediators or moderators resulted in reduced model fit, highlighting the critical roles of innovation capabilities, internal capabilities, and market knowledge breadth, as well as firm privacy concern, in shaping the big data analytics capabilities-new product development relationship.



The robustness of the conceptual framework was further supported by alternative model testing. These analyses demonstrated that big data analytics capabilities alone are insufficient to drive new product development outcomes without the mediating influence of organizational capabilities. This reinforces the need for firms to invest in complementary resources and align their big data analytics capabilities strategy with privacy regulations to maximize innovation outcomes in privacy-sensitive sectors like healthcare. However, the effect of big data analytics capabilities on internal capabilities was not significant ($b = 0.1238$, $t = 1.2250$, $p = 0.2215$), suggesting no substantial impact in this area. Interestingly, a significant negative effect was observed between big data analytics capabilities and market knowledge breadth ($b = -0.2512$, $t = -2.3770$, $p = 0.0180$), pointing to a possible reduction in market knowledge breadth as analytics capabilities increase.

Direct Effects - A visual summary of the direct effects is provided in Figure 1 to enhance clarity and coherence in presenting the results. As shown in Table 4, big data analytics capabilities have a substantial positive direct effect on innovation capabilities ($b = 0.8676$, $t = 50.4962$, $p < 0.001$). The effect size ($f^2 = 0.75$) is large, emphasizing the significant role of big data analytics capabilities in fostering innovation within organizations. However, the direct effect of big data analytics capabilities on internal capabilities ($b = 0.1238$, $t = 1.2250$, $p = 0.2215$) is not significant, indicating a limited impact in this area. Additionally, big data analytics capabilities exhibit a significant but negative direct effect on market knowledge breadth ($b = -0.2512$, $t = -2.3770$, $p = 0.0180$), suggesting that increased analytics capabilities may narrow the organization's market exploration focus.

Indirect Effects - The indirect effect of big data analytics capabilities on new product development through innovation capabilities is significant (Effect = 0.3392, BootSE = 0.1435, BootLLCI = 0.0587, BootULCI = 0.6179), supporting Hypothesis 1a. The indirect effect through internal capabilities is also significant (Effect = 0.0205, BootSE = 0.0128, BootLLCI = 0.0004, BootULCI = 0.0505), supporting Hypothesis 1b. However, the indirect effect through market knowledge breadth is insignificant (Effect = -0.0019, BootSE = 0.0086, BootLLCI = -0.0226, BootULCI = 0.0132), rejecting Hypothesis 1c. These findings underscore the central role of innovation and internal capabilities in mediating the relationship between big data analytics capabilities and new product development outcomes, while market knowledge breadth appears to play a less influential role.

The interaction effects examine the moderating role of firm privacy concern. The results indicate that firm privacy concern significantly attenuates the relationship between big data analytics capabilities and innovation capabilities ($b = -0.0357$, $t = -6.6863$, $p < 0.001$),

suggesting that higher privacy concerns weaken the positive effect of big data analytics on innovation outcomes. However, the moderation effects of firm privacy concern on the relationships between big data analytics capabilities and internal capabilities ($b = -0.0119$, $t = -0.3786$, $p = 0.7052$) and market knowledge breadth ($b = -0.0449$, $t = -1.3680$, $p = 0.1723$) are not statistically significant.

The large direct effect of big data analytics capabilities on innovation capabilities ($b = 0.8676$, $f^2 = 0.75$) aligns with theoretical expectations that analytics capabilities directly enhance innovation by generating actionable insights and enabling data-driven decision-making. The disparity between the regression coefficient and the correlation coefficient in Table 3 ($r = 0.253$) can be attributed to the inclusion of control variables and the mediating effects of other constructs in the regression analysis, which isolate the unique contribution of big data analytics capabilities to innovation capabilities. To ensure robustness and transparency, effect sizes (f^2) and model statistics (R , F -tests, and p -values) are reported for all tested models. The model demonstrates a substantial ability to explain variance in innovation capabilities ($R^2 = 0.95$, $F = 875.83$). Effect sizes indicate substantial impacts for key relationships, with big data analytics capabilities having a large effect on innovation capabilities ($f^2 = 0.75$) and a moderate effect on internal capabilities ($f^2 = 0.12$). These results highlight that while big data analytics capabilities are critical drivers of innovation, they must be complemented by organizational investments in internal capabilities and strategies to mitigate privacy concerns. Additionally, the negative direct effect of big data analytics capabilities on market knowledge breadth suggests a trade-off between analytics-driven efficiency and market exploration, warranting further investigation into balancing these dynamics.

<<<Please insert Table 4>>>

Discussion

This study integrates the healthcare context into a broader theoretical framework, building on the structured approach of Stremersch et al. (2023). Healthcare represents a unique setting where stringent privacy regulations (e.g., GDPR, HIPAA) and rapid innovation pressures converge. By examining the role of big data analytics capabilities in enhancing new product development, the study offers pivotal insights into how data-driven innovation drives advancements in treatments, medical devices, and patient care technologies. Our findings emphasize that big data analytics capabilities alone are insufficient to achieve innovation outcomes. Instead, complementary innovation capabilities and internal capabilities are critical mediators that enable firms to transform data into actionable outcomes. Innovation capabilities allow organizations to leverage data insights in order to develop patient-centered solutions like diagnostic tools and personalized treatments (Teece, 2007), while internal capabilities ensure robust infrastructure, skilled personnel, and structured processes for managing and integrating data effectively (Aker et al., 2016; Wamba et al., 2017). Without these foundational capabilities, big data analytics capabilities may not reach their full potential in supporting new product development.

Interestingly, market knowledge breadth did not significantly impact new product development outcomes, which contrasts with literature linking a broader market understanding to innovation success. The findings further emphasize the role of service innovation as a critical pathway for translating big data insights into meaningful healthcare outcomes. Unlike traditional product innovation, service innovation leverages co-creation with patients and dynamic capabilities to enhance care delivery. This approach is particularly relevant in regulated industries like healthcare, where privacy constraints necessitate a focus on internal efficiencies and patient engagement rather than broad market exploration. By adopting service-oriented frameworks, healthcare firms can bridge the gap between data-driven insights and the tangible improvements required in patient outcomes. In the healthcare context, firms often prioritize internal data-driven processes and operational efficiencies over external market exploration due to privacy constraints. Regulations such as GDPR and HIPAA restrict the collection and use of external market data, shifting firms' focus toward high-quality, internally sourced patient and clinical data. Moreover, the specialized nature of healthcare innovation—centered on improving patient outcomes—often relies less on broad market scanning and more on targeted, internal insights. These results suggest that the relevance of market knowledge breadth to new product development is context-dependent,



particularly in privacy-sensitive industries where external market engagement is constrained. Practically, healthcare firms must strike a balance between leveraging internal capabilities and selectively exploring external market opportunities where feasible. Future research could examine the conditions under which market knowledge breadth becomes more critical, such as in less regulated industries or firms with more flexibility to acquire external market knowledge.

The study also highlights the moderating role of firm privacy concern, which reflects the trade-offs between data-driven innovation and privacy compliance. When privacy concerns are high, organizations may limit data collection and sharing, thus constraining big data analytics capabilities' ability to support innovation. This effect is particularly evident in the relationship between big data analytics capabilities and innovation capabilities, where privacy restrictions may hinder firms' ability to use data for ideation and product development (Saarikko et al., 2020). However, privacy concerns do not significantly impact big data analytics capabilities' relationship with internal capabilities, suggesting that while external data collection is restricted, firms can still process and utilize internal data effectively. These findings contribute to both theoretical and practical perspectives. Theoretically, the study extends the resource-based view by showing that big data analytics capabilities require complementary organizational capabilities to drive innovation, especially in regulated industries. It also introduces firm privacy concern as a contextual moderator, redefining resource complementarities under privacy constraints. Practically, it provides actionable insights for healthcare managers, emphasizing the need to balance internal efficiencies with limited external market engagement while aligning big data analytics capabilities strategies with privacy regulations. In conclusion, this study advances understanding of how big data analytics capabilities influence new product development in the healthcare industry, where regulatory constraints and data sensitivity pose unique challenges. By addressing the mediating roles of innovation capabilities and internal capabilities and the moderating role of firm privacy concern, the study highlights the importance of strategic data management practices to optimize innovation outcomes. It also uncovers the contextual limitations of market knowledge breadth in regulated industries, offering a framework for adapting resource utilization strategies to sector-specific constraints and opportunities.



Theoretical Contributions

Our study strengthens the resource-based view by demonstrating that big data analytics capabilities alone are insufficient to drive innovation outcomes. Instead, firms require complementary organizational resources, such as innovation capabilities and internal capabilities, to transform data into actionable outcomes. Specifically, innovation capabilities enable firms to leverage big data insights to develop novel products and services, aligning with dynamic capabilities theory (Teece, 2007). Meanwhile, internal capabilities provide the foundational infrastructure, skilled workforce, and processes needed to integrate and manage big data effectively. In healthcare, innovation capabilities are closely tied to service innovation, as organizations aim to enhance patient-centered solutions through co-creation and adaptability. By embedding service innovation principles into their big data analytics strategies, firms can better address the dual pressures of regulatory compliance and operational efficiency.

This study extends the resource-based view by addressing how regulatory constraints, such as GDPR and HIPAA, redefine resource complementarities in privacy-sensitive industries like healthcare. The interaction between firm privacy concern and big data analytics capabilities highlights the dual challenge firms face; while analytics capabilities enhance innovation and operational efficiencies, heightened privacy concerns can restrict the flexibility needed to explore external market knowledge.

Furthermore, our research bridges established resource-based view principles with emerging theories on data ethics and organizational agility. In highly regulated environments, ethical considerations surrounding data collection and utilization add complexity to resource management requiring firms to balance compliance with innovation goals. Incorporating organizational agility offers a dynamic perspective, showing how firms can adapt their data-driven strategies to navigate privacy regulations while maintaining responsiveness to innovation demands. By integrating these perspectives, our study challenges the assumption that big data analytics capabilities uniformly enhance all organizational outcomes. It provides a more nuanced understanding of resource utilization in regulated industries and contributes to evolving discussions on data-driven innovation. This theoretical framework highlights the importance of resource complementarities under complex regulatory and ethical constraints.

Managerial Implications

The study provides practical strategies for managers to maximize the potential of big data analytics capabilities while addressing the challenges posed by high privacy concerns. Industries operating under stringent regulatory environments—such as healthcare, finance, and legal services—face a critical trade-off between driving innovation through data and complying with privacy regulations like GDPR in Europe, HIPAA in the United States, and emerging frameworks such as CCPA in California. The global market for big data analytics is projected to reach \$745 billion by 2030 (Grand View Research, 2024), fueled by the increasing adoption of advanced analytics across industries. However, privacy regulations limit external data collection, especially in highly sensitive sectors. In healthcare, for example, compliance with HIPAA restricts external data-sharing but emphasizes patient-centered innovation. Similar challenges are faced in finance, where sensitive customer information must be protected, and in retail, where firms must navigate data tracking regulations to maintain consumer trust.

To overcome these challenges, firms must first develop privacy-centric data governance frameworks. Managers should implement policies that ensure compliance with global privacy regulations while enabling data-driven innovation. Techniques such as data anonymization, data minimization, and differential privacy allow firms to extract valuable insights without exposing personal data. For example, financial institutions use data masking to protect sensitive transaction information during fraud detection, balancing security with analytical needs. Second, investing in privacy-enhancing technologies is essential for securely processing sensitive data. Tools such as encryption methods, federated learning, and secure multi-party computation allow organizations to analyze data without compromising privacy. In healthcare, federated learning models enable hospitals to train machine learning algorithms collaboratively without sharing raw patient data. Similarly, in retail, encrypted transactional data can be used for consumer behavior analytics while maintaining compliance with privacy laws. Enhancing organizational agility is another key strategy for managers. Firms must develop adaptive processes that allow them to respond quickly to changes in privacy regulations. Cross-functional collaboration between legal, IT, and R&D teams is critical to embedding privacy compliance into every stage of the innovation process. For instance, financial service firms often use iterative testing and prototyping to align product development with evolving privacy frameworks, ensuring that regulatory constraints do not hinder innovation.

Given the limitations on external data access, firms should prioritize internal data utilization and integration. Managers can invest in systems that optimize clinical, operational, and customer-level data to generate actionable insights. For example, in healthcare, hospitals using predictive analytics on internal patient data have reduced readmission rates by up to 40%. In manufacturing, internal machine-generated data supports predictive maintenance, improving operational efficiency while minimizing external dependencies. Building trust and transparency with stakeholders is also vital for overcoming privacy-related challenges. Ethical data practices, such as clear privacy policies and transparent disclosures, can help reassure customers, regulators, and partners about responsible data usage. For example, banks that emphasize ethical data handling and transparency have successfully enhanced customer confidence, leading to greater willingness to share data for personalized financial solutions.

To address the trade-off between operational efficiency and market exploration, firms can adopt external data partnerships. Collaborating with compliant third parties, such as anonymized data platforms, research institutions, or government-backed data repositories, allows organizations to access diverse market insights while adhering to privacy laws. For instance, pharmaceutical companies often partner with universities to analyze anonymized clinical trial data for new drug development, balancing innovation with compliance. While big data analytics capabilities offer significant opportunities for innovation, their use raises ethical concerns related to data privacy, informed consent, and algorithmic bias. Managers must align their data strategies with principles of transparency, fairness, and accountability to mitigate these risks. Over-reliance on big data may inadvertently introduce biases, particularly in sensitive industries like healthcare and finance, where incomplete datasets can disadvantage underrepresented populations. To address these ethical challenges, firms should implement bias-detection frameworks to ensure fairness in data-driven decisions and regularly audit algorithms for unintended consequences. Additionally, prioritizing informed consent ensures individuals understand how their data will be used, fostering trust and minimizing ethical dilemmas.

By balancing innovation with social responsibility, firms can build credibility while adhering to regulatory requirements. By adopting privacy-centric governance frameworks, leveraging privacy-enhancing technologies, fostering organizational agility, and developing trusted partnerships, managers can overcome the challenges posed by high privacy concerns. These strategies allow firms to fully exploit the potential of big data analytics capabilities while maintaining compliance with evolving privacy regulations. Addressing ethical considerations ensures firms not only drive innovation



but also maintain stakeholder trust, creating a competitive advantage in privacy-sensitive environments.

To enhance the applicability of the findings, organizations can consider strategies from other highly regulated industries, such as finance or retail. For example, financial institutions manage compliance with GDPR while leveraging big data analytics to offer personalized financial services, demonstrating how privacy-preserving technologies like federated learning can drive innovation without compromising data security. Similarly, retail companies employ anonymized customer data for targeted marketing, showcasing how robust privacy policies can facilitate innovation while maintaining customer trust. In healthcare, similar approaches—such as adopting differential privacy or collaborating with technology providers—can help organizations balance innovation and privacy concerns effectively.

Limitations and Future Research

This study highlights the need for further exploration of the dynamic relationship between big data analytics capabilities and privacy regulations, particularly as new regulatory frameworks emerge globally. Table 5 provides a clear and concise summary, making it easier for practitioners to apply the findings to their strategic decision-making processes. While we considered the moderating role of existing privacy laws such as GDPR and HIPAA, future research should examine the impact of emerging regulations (e.g., CCPA in California, India's DPDP Act, and China's PIPL) on firms' ability to leverage big data analytics capabilities for innovation outcomes. First, longitudinal studies could investigate how firms adapt their data management practices in response to evolving privacy regulations. Such studies could reveal the long-term effects of compliance strategies on innovation processes, including new product development, and provide insights into how firms align regulatory adherence with resource utilization. Second, future research could conduct cross-industry comparative studies to explore how privacy regulations impact big data analytics capabilities in sectors with varying regulatory intensities, such as healthcare, finance, and retail. Such studies would help clarify whether the findings from healthcare are generalizable to less regulated industries and uncover sector-specific strategies for addressing privacy challenges while driving innovation. Additionally, case studies from regulated industries, such as finance or retail, could identify best practices for managing the trade-off between privacy concerns and innovation. Cross-country studies could further examine how organizations in diverse regulatory environments adopt privacy-preserving innovation strategies, offering deeper insights into the generalizability of the findings.



Third, future research could examine the role of organizational agility and data governance frameworks as critical enablers for navigating privacy regulations. By assessing how firms balance compliance with innovation imperatives, researchers can identify actionable strategies for achieving data-driven innovation in restrictive regulatory environments. Fourth, emerging theories on data ethics and trust could be integrated to explore how firms' ethical practices influence their ability to leverage big data analytics capabilities. Understanding the role of transparency, trust-building, and ethical considerations in mitigating privacy concerns would provide valuable theoretical and managerial insights.

This study also acknowledges several limitations that future research could address. First, the exclusive focus on the UK healthcare sector may limit the generalizability of the findings. Future studies could extend the analysis to other privacy-sensitive sectors, such as finance or legal services, to examine the broader applicability of the results. Cross-industry comparisons could further reveal how varying regulatory intensities influence the big data analytics capabilities-new product development relationship. Second, the use of cross-sectional data restricts the ability to establish causal relationships between mediators of big data analytics capabilities and new product development outcomes. Future research could employ longitudinal designs to capture the evolving nature of organizational capabilities and privacy concerns, providing a more robust understanding of big data analytics capabilities' long-term impact on innovation. Third, the reliance on key informants, including employees and managers, is a limitation of this study, as informant accuracy may vary based on hierarchical level, access to information, and interpretive abilities (Homburg et al., 2012). Future research could address this by using a multi-informant approach or applying multilevel modeling to account for hierarchical data structures, providing a more nuanced understanding of organizational and individual-level interactions. Fourth, a reliance on self-reported data introduces the risk of CMB, despite efforts to mitigate this effect. Incorporating objective data sources or triangulating with secondary data would enhance validity and strengthen causal inferences.

Lastly, future studies could explore additional mediators and moderators influencing the big data analytics capabilities-new product development relationship, such as organizational culture, regulatory intensity, and market volatility. Examining these variables across diverse cultural and regulatory contexts would offer deeper insights into managing data-driven innovation within privacy-sensitive environments. By



addressing these areas and expanding the scope of analysis, future research can build on this study to provide a more comprehensive understanding of the role of big data analytics capabilities in driving innovation across industries and regions. For example, exploring industries with varying levels of data privacy regulations, such as finance or retail, could offer deeper insights into the interplay between big data analytics, innovation processes, and privacy concerns. Furthermore, cross-country studies could examine how differing regulatory frameworks shape these relationships, enhancing the generalizability of the findings. Future studies also could explore the use of structural equation modeling to simultaneously estimate complex mediated and moderated relationships, offering a more comprehensive view of the interdependencies between big data analytics capabilities, innovation outcomes, and privacy concerns.



References:

1. Acciarini, C., Cappa, F., Boccardelli, P., & Oriani, R. (2023). How can organizations leverage big data to innovate their business models? A systematic literature review. *Technovation*, 123(May), 102713.
2. Acquisti, A., Taylor, C. R., & Wagman, L. (2016). The economics of privacy. *Journal of Economic Literature*, 54(2), 442492-.
3. Akter, S., Wamba, S. F., Gunasekaran, A., Dubey, R., & Childe, S. J. (2016). How to improve firm performance using big data analytics capability and business strategy alignment? *International Journal of Production Economics*, 182, 113131-.
4. Akter, S., Wamba, S. F., Gunasekaran, A., Dubey, R., & Childe, S. J. (2016). How to improve firm performance using big data analytics capability and business strategy alignment? *International Journal of Production Economics*, 182, 113131-.
5. Anderson, C. L., & Agarwal, R. (2011). The digitization of healthcare: boundary risks, emotion, and consumer willingness to disclose personal health information. *Information Systems Research*, 22(3), 469490-.
6. Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99120-.
7. Behl, A., Kamboj, S., Sharma, N., Pereira, V., Salwan, P., Chavan, M., & Pathak, A. A. (2023). Linking dynamic absorptive capacity and service innovation for born global service firms: An organization innovation lens perspective. *Journal of International Management*, 29(4), 101044.
8. Bélanger, F., & Crossler, R. E. (2011). Privacy in the digital age: a review of information privacy research in information systems. *MIS Quarterly*, 35(4), 10171042-.
9. Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: An empirical investigation. *MIS Quarterly*, 24(1), 169196-.
10. Borah, P. S., Dogbe, C. S. K., Pomegbe, W. W. K., Bamfo, B. A., & Hornuvo, L. K. (2023). Green market orientation, green innovation capability, green knowledge acquisition and green brand positioning as determinants of new product success. *European Journal of Innovation Management*, 26(2), 364385-.
11. Bouschery, S. G., Blazevic, V., & Piller, F. T. (2023). Augmenting human innovation teams with artificial intelligence: Exploring transformer-based language models. *Journal of Product Innovation Management*, 40(2), 139153-.



12. Calantone, R. J., Cavusgil, S. T., & Zhao, Y. (2002). Learning orientation, firm innovation capability, and firm performance. *Industrial Marketing Management*, 31(6), 515-524.
13. Chang, V., Xu, Q. A., Hall, K., Wang, Y. A., & Kamal, M. M. (2023). Digitalization in omnichannel healthcare supply chain businesses: The role of smart wearable devices. *Journal of Business Research*, 156(Feb), 1133-69.
14. Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. *MIS Quarterly*, 36(4), 1165-1188.
15. Ciampi, F., Demi, S., Magrini, A., & Marzi, G. (2021). Exploring the impact of big data analytics capabilities on business model innovation: The mediating role of entrepreneurial orientation. *Journal of Business Research*, 123, 113-.
16. Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1), 128-152.
17. Culnan, M. J., & Williams, C. C. (2009). How ethics can enhance organizational privacy: Lessons from the choicepoint and TJX data breaches. *MIS Quarterly Executive*, 8(4), 127-142.
18. Culnan, M. J., & Williams, C. C. (2009). How ethics can enhance organizational privacy: lessons from the choicepoint and TJX data breaches. *MIS Quarterly*, 33(4), 673-687.
19. Davenport, T. H. (2013). Analytics 3.0. *Harvard Business Review*, 91(12), 64-72.
20. Day, G. S. (1994). The capabilities of market-driven organizations. *Journal of Marketing*, 58(4), 375-2.
21. de Hert, P., Papakonstantinou, V., Malgieri, G., Beslay, L., & Sanchez, I. (2018). The right to data portability in the GDPR: Towards user-centric interoperability of digital services. *Computer Law & Security Review*, 34(2), 193-203.
22. De Luca, L. M., & Atuahene-Gima, K. (2007). Market knowledge dimensions and cross-functional collaboration: Examining the different routes to product innovation performance. *Journal of Marketing*, 71(1), 95-112.
23. Ferraris, A., Mazzoleni, A., Devalle, A., & Couturier, J. (2019). Big data analytics capabilities and knowledge management: Impact on firm performance. *Management Decision*, 57(8), 1923-1936.
24. Ferraris, A., Mazzoleni, A., Devalle, A., & Couturier, J. (2019). Big data analytics capabilities and knowledge management: impact on firm performance. *Management Decision*, 57(8), 1923-1936.



25. Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 3950-.
26. Gandomi, A., & Haider, M. (2015). Beyond the hype: Big data concepts, methods, and analytics. *International Journal of Information Management*, 35(2), 137144-.
27. Ghasemaghaei, M., Hassanein, K., & Turel, O. (2017). Increasing firm agility through the use of data analytics: The role of flexibility and its impact on firm performance. *Journal of Strategic Information Systems*, 26(2), 101118-.
28. Goodman, L. A. (1961). Snowball sampling. *The Annals of Mathematical Statistics*, 32(1), 148170-.
29. Grego, M., Bartosiak, M., Palese, B., Piccoli, G., & Denicolai, S. (2024). Disentangling the 'digital': A critical review of information technology capabilities, information technology-enabled capabilities and digital capabilities in business research. *International Journal of Management Reviews*.
30. Grover, V., Chiang, R. H., Liang, T. P., & Zhang, D. (2018). Creating strategic business value from big data analytics: A research framework. *Journal of Management Information Systems*, 35(2), 388423-.
31. Gupta, M., & George, J. F. (2016). Toward the development of a big data analytics capability. *Information & Management*, 53(8), 10491064-.
32. Hamilton, R. H., & Sodeman, W. A. (2020). The questions we ask: Opportunities and challenges for using big data analytics to strategically manage human capital resources. *Business Horizons*, 63(1), 8595-.
33. healthcatalyst.com (2024) https://www.healthcatalyst.com/learn/insights/reducing-hospital-readmissions-value-analytics?utm_source=chatgpt.com
34. Homburg, C., Klarmann, M., Reimann, M., & Schilke, O. (2012). What drives key informant accuracy?. *Journal of Marketing Research*, 49(4), 594608-.
35. Huston, L., & Sakkab, N. (2006). Connect and develop: Inside Procter & Gamble's new model for innovation. *Harvard Business Review*, 84(3), 5866-.
36. Huynh, M. T., Nippa, M., & Aichner, T. (2023). Big data analytics capabilities: Patchwork or progress? A systematic review of the status quo and implications for future research. *Technological Forecasting and Social Change*, 197(Dec), 122884.
37. Isaak, J., & Hanna, M. J. (2018). User data privacy: Facebook, Cambridge Analytica, and privacy protection. *Computer*, 51(8), 5659-.



38. Jaspers, R., & Pearson, R. (2022). Privacy concerns in digital transformation: Implications for data-driven business practices. *Journal of Business Research*, 143, 8797-.
39. Jaworski, B. J., & Kohli, A. K. (1993). Market orientation: Antecedents and consequences. *Journal of Marketing*, 57(3), 5370-.
40. Jiang, Y., Feng, T., & Huang, Y. (2024). Antecedent configurations toward supply chain resilience: The joint impact of supply chain integration and big data analytics capability. *Journal of Operations Management*, 70(2), 257284-.
41. Kiron, D., Prentice, P. K., & Ferguson, R. B. (2014). The analytics mandate. *MIT Sloan Management Review*, 55(4), 125-.
42. Lambert, D. M., & Harrington, T. C. (1990). Measuring nonresponse bias in customer service mail surveys. *Journal of Business Logistics*, 11(2), 525-.
43. Li, T., & Atuahene-Gima, K. (2001). Product innovation strategy and the performance of new technology ventures in China. *Academy of Management Journal*, 44(6), 11231134-.
44. Lin, Y., & Kunnathur, A. (2019). The development of big data analytics measures: Insights from item generation to validation. *Journal of Business Analytics*, 2(1), 15-32.
45. MacKenzie, S. B., & Podsakoff, P. M. (2012). Common method bias in marketing: Causes, mechanisms, and procedural remedies. *Journal of Retailing*, 88(4), 542555-.
46. Malhotra, N. K., Kim, S. S., & Patil, A. (2006). Common method variance in IS research: A comparison of alternative approaches and a reanalysis of past research. *Management Science*, 52(12), 18651883-.
47. Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Hung Byers, A. (2011). *Big data: The next frontier for innovation, competition, and productivity*. McKinsey Global Institute.
48. Martin, K. D., Borah, A., & Palmatier, R. W. (2017). Data privacy: Effects on customer and firm performance. *Journal of Marketing*, 81(1), 3658-.
49. McDaniel, C., & Gates, R. (2006). *Marketing research essentials*. John Wiley & Sons.
50. Mikalef, P., Boura, M., Lekakos, G., & Krogstie, J. (2019). Big data analytics capabilities and innovation: the mediating role of dynamic capabilities and moderating effect of the environment. *British Journal of Management*, 30(2), 272298-.



51. Mikalef, P., Pappas, I. O., Krogstie, J., & Giannakos, M. (2018). Big data analytics capabilities: A systematic literature review and research agenda. *Information Systems and e-Business Management*, 16(3), 547578-.
52. mordorintelligence.com (2024) https://www.mordorintelligence.com/industry-reports/big-data-healthcare?utm_source=chatgpt.com
53. O'Reilly, C. A., & Tushman, M. L. (2008). Ambidexterity as a dynamic capability: Resolving the innovator's dilemma. *Research in Organizational Behavior*, 28, 185-206.
54. Pavlou, P. A. (2011). State of the information privacy literature: Where are we now and where should we go? *MIS Quarterly*, 35(4), 977988-.
55. Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879903-.
56. Quach, S., Thaichon, P., Martin, K. D., Weaven, S., & Palmatier, R. W. (2022). Digital technologies: tensions in privacy and data. *Journal of the Academy of Marketing Science*, 50(6), 12991323-.
57. Ross, J. W., Beath, C. M., & Quaadgras, A. (2013). You may not need big data after all. *Harvard Business Review*, 91(12), 9098-.
58. Saarikko, T., Westergren, U. H., & Blomquist, T. (2020). Digital transformation: Five recommendations for the digitally conscious firm. *Business horizons*, 63(6), 825-839.
59. Sahi, G. K., Modi, P., & Mantok, S. (2023). New product innovations in times of crisis: How did women entrepreneurs survive the COVID-19 crisis?. *Industrial Marketing Management*, 111, 1929-.
60. Sekaran, U. (2003). *Research methods for business: A skill-building approach*. John Wiley & Sons.
61. Sivarajah, U., Kamal, M. M., Irani, Z., & Weerakkody, V. (2017). Critical analysis of Big Data challenges and analytical methods. *Journal of Business Research*, 70(Jan), 263286-.
62. Sjödin, D., Liljeborg, A., & Mutter, S. (2024). Conceptualizing ecosystem management capabilities: Managing the ecosystem-organization interface. *Technological Forecasting and Social Change*, 200(March), 123187.
63. Smith, H. J., Dinev, T., & Xu, H. (2011). Information privacy research: An

- interdisciplinary review. *MIS Quarterly*, 35(4), 9891016-.
64. Smith, H. J., Dinev, T., & Xu, H. (2011). Information privacy research: an interdisciplinary review. *MIS Quarterly*, 35(4), 9891015-.
 65. Srinivasan, R., & Swink, M. (2018). An investigation of visibility and flexibility as complements to supply chain analytics: A dynamic capabilities framework. *Production and Operations Management*, 27(10), 18491867-.
 66. straitsresearch.com (2024) <https://straitsresearch.com/report/big-data-in-healthcare-market>
 67. Stremersch, S., Gonzalez, J., Valenti, A., & Villanueva, J. (2023). The value of context-specific studies for marketing. *Journal of the Academy of Marketing Science*, 51(1), 5065-.
 68. Subramaniam, M., & Youndt, M. A. (2005). The influence of intellectual capital on the types of innovative capabilities. *Academy of Management Journal*, 48(3), 450-463.
 69. Upadhyay, P., & Kumar, A. (2020). The intermediating role of organizational culture and internal analytical knowledge between the capability of big data analytics and a firm's performance. *International Journal of Information Management*, 52, 102100.
 70. Vidgen, R., Shaw, S., & Grant, D. B. (2017). Management challenges in creating value from business analytics. *European Journal of Operational Research*, 261(2), 626639-.
 71. Wamba, S. F., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2017). How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics*, 165, 234246-.
 72. Wamba, S. F., Gunasekaran, A., Akter, S., Ren, S. J. F., Dubey, R., & Childe, S. J. (2017). Big data analytics and firm performance: Effects of dynamic capabilities. *Journal of Business Research*, 70(Jan), 356365-.
 73. Wang, C., Chen, K., Feng, J., & Chen, J. (2024). Donating or collecting? Differential impact mechanisms of knowledge sharing through enterprise social media on employees' innovative work behavior. *Information Technology & People*.
 74. Wang, S., & Zhang, H. (2024). Inter-organizational cooperation in digital green supply chains: A catalyst for eco-innovations and sustainable business practices. *Journal of Cleaner Production*, 472(Sep), 143383.



75. Xu, H., Teo, H. H., Tan, B. C., & Agarwal, R. (2012). Effects of individual self-protection, industry self-regulation, and government regulation on privacy concerns: A study of location-based services. *Information Systems Research*, 23(4), 13421363-.
76. Yasmin, M., Tatoglu, E., Kilic, H. S., Zaim, S., & Delen, D. (2020). Big data analytics capabilities and firm performance: An integrated MCDM approach. *Journal of Business Research*, 114(June), 115-.
77. Ye, J., Shi, S., & Feng, Y. (2024). The effects of market orientation and market knowledge search on business model innovation: Evidence for two distinct pathways. *European Journal of Innovation Management*, 27(8), 27292752-.
78. Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, 27(2), 185203-.

Table 1: Respondents' characteristics n= (324)

Gender	Frequency	Percent	Age		
Male	137	42.3	Under 25	38	11.7
Female	187	57.7	25-34	63	19.4
Education			35-44	193	59.6
PhD	24	7.4	45-54	30	9.3
Postgraduate	173	53.4	Position		
Undergraduate	126	38.9	Chief Executive	69	21.3
Pre-university	1	3.	Senior Management	63	19.4
			Middle Management	106	32.7
			Junior Management	86	26.5

Table 2: Descriptive, reliability and validity

Codes	Item measurements	Factor Loading	Mean	Std. Deviation
Big Data Analytics Capabilities Akter et al., 2016, Srinivasan and Swink, 2018 Definition: Big data analytics capabilities refer to an organization's ability to effectively collect, process, and analyze large, complex datasets to generate actionable insights that support decision-making, innovation, and competitive advantage. These capabilities combine technological resources, human expertise, and organizational practices to transform data into strategic assets (Akter et al., 2016; Huynh et al., 2023; Jjiang et al., 2024; Srinivasan and Swink, 2018)	We use advanced tools (like optimization/regression/simulation) for data analysis.	795.	5.50	1.539
	We use data visualization techniques to assist decision-makers in understanding complex information extracted from large data	808.	5.44	1.568
	Our dashboards display information, which is useful for carrying out the necessary diagnosis	926.	5.78	1.434
	We have connected dashboard applications or information with the manager's communication devices	896.	5.86	1.458
	Cronbach's alpha = .919			
Innovation Capabilities (Foroudi et al., 2016)	Definition: Innovation capabilities encompass an organization's ability to leverage knowledge, skills, and structured procedures to engage in technical, non-technical, marketing, and service innovations (Behl et al., 2023; Foroudi et al., 2016; Wang & Zhang, 2024)	Cronbach's alpha = .969		

Codes	Item measurements	Factor Loading	Mean	Std. Deviation
INNC1	We use knowledge to engage in technical innovations			
INNC2	We use skills to engage in technical innovations	925.	4.10	2.317
INNC3	We use knowledge to engage in non-technical innovation	918.	4.20	2.300
INNC4	We have procedures for marketing innovations	916.	4.22	2.296
INNC5	We have procedures in our organization for Services innovations	865.	4.79	1.844
Internal Capabilities (Germann et al. (2013		Cronbach's alpha = .944		
IC1	Our employees are very good at identifying and employing the appropriate customer analysis tool and technique given the problem at hand	880.	4.05	2.33
IC2	Our employees master many different quantitative customer analysis tools and techniques	812.	4.68	2.122
IC3	Our employees can be considered as experts in customer analytics	891.	4.29	2.382
Market Knowledge Breadth (Ozdemir et al. (2024		Cronbach's alpha = .930		
IC1	Our employees are very good at identifying and employing the appropriate customer analysis tool and technique given the problem at hand	880.	4.05	2.33
IC2	Our employees master many different quantitative customer analysis tools and techniques	812.	4.68	2.122
IC3	Our employees can be considered as experts in customer analytics	891.	4.29	2.382
Market Knowledge Breadth (Ozdemir et al. (2024		Cronbach's alpha = .930		
Definition: Market knowledge breadth refers to the diversity and comprehensiveness of an organization's understanding of its external environment, including customer preferences, competitor strategies, industry trends, and market dynamics. It reflects the firm's ability to acquire and integrate a wide range of information from various market-related sources to inform strategic decisions and foster innovation.				

Codes	Item measurements	Factor Loading	Mean	Std. Deviation
MKB1	We possess market information from a diversified customer portfolio	929.	5.15	1.725
MKB2	We have accumulated knowledge of multiple market segments	886.	4.93	1.916
MKB3	.Our R&D expertise consists of knowledge from a variety of background	878.	5.35	1.599
New Product Development Process				
Atuahene-Gima and Ko, 2001; Moorman, 1995				
Definition: The new product development process refers to a structured sequence of activities and decisions through which organizations conceptualize, design, develop, and launch new products or services. It encompasses all stages from idea generation to commercialization, integrating cross-functional efforts to create offerings that meet customer needs, address market opportunities, and achieve organizational goals ((Atuahene-Gima and Ko, 2001; Borah et al., 2023; Bouschery et al., 2023; Moorman, 1995; Sahi et al., 2023				
NPD1	In the last 3 years, new products/services at my firm generally achieved their market share objectives	834.	5.49	1.765
NPD2	In the last 3 years, new products/services at my firm generally achieved their sales and customer use objectives	920.	5.67	1.654
NPD3	In the last 3 years, new products/services at my firm generally achieved their sales growth objectives	942.	5.84	1.702
NPD4	In the last 3 years, new products/services at my firm generally achieved their profit objectives	937.	5.85	1.699
Firm Privacy Concern				
Jaspers, and Pearson, 2022				
Definition: Firm privacy concern, as conceptualized as the degree to which an organization is sensitive to privacy-related risks, prioritizes data protection and complies with regulatory frameworks (Bélanger & Crossler, 2011; Culnan & Williams, 2009; Smith et al., 2011				
		Cronbach's alpha = .960		
		Cronbach's alpha = .935		

Codes	Item measurements	Factor Loading	Mean	Std. Deviation
FRC1	Our organization is concerned that data collected from IoT devices could be used for inappropriate purposes			
FRC2	Our organization is concerned that data collected from IoT devices could be accessed by unauthorized parties			
FRC3	Our organization carefully evaluates risks before providing or gathering personal information through IoT devices	859.	4.8796	2.00642
FRC4	Our organization is concerned that IoT devices may be collecting excessive amounts of personal information	866.	4.8704	2.13083
FRC5	Our organization is concerned that data collected from IoT devices could be used in ways we are not fully aware of	844.	5.2222	1.88525

Table 3: Validity, Reliability, and Correlation Matrix

	CR	AVE	MSV	(MaxR(H	Market Knowledge Breadth	Big Data Analytics Capabilities	Internal Capabilities	Innovation Capabilities	Inter-Internal Capabilities	New Product Development Process
Market Knowledge Breadth	0.934	0.825	0.138	0.940	0.908					
Big Data Analytics Capabilities	0.922	0.748	0.163	0.942	0.241	0.865				
Internal Capabilities	0.971	0.893	0.381	0.978	0.249	0.189	0.945			
Innovation Capabilities	0.947	0.857	0.381	0.986	0.253	0.116	0.617	0.926		
New Product Development Process	0.960	0.860	0.163	0.988	0.371	0.404	0.167	0.133	0.927	
Chi-square = 251.810; Degrees of freedom = 125; CFI: .982; TLI: .978; IFI: .980; RFI: .957; NFI: .965; RMSEA: .056										

Table 4: Hypotheses results

Direct effect	Coeff	SE	t	P	LLCI	ULCI	Sig/Insig
Big data analytics capabilities -> Innovation capabilities	0.8676	0.0172	50.4962	0.0000	0.8338	0.9014	Supported
Big data analytics capabilities -> Internal capabilities	0.1238	0.1011	1.2250	0.2215	-0.0751	0.3227	Not Supported
Big data analytics capabilities -> Market knowledge breadth	-0.2512	0.1057	-2.3770	0.0180	-0.4591	-0.0433	Supported
Innovation capabilities -> New product development process	0.3485	0.2849	1.2230	0.2222	-0.2122	0.9091	Not Supported
Internal capabilities -> New product development process	0.1288	0.0571	2.2570	0.0247	0.0165	0.2411	Supported
Market knowledge breadth -> New product development process	0.0162	0.0545	0.2983	0.7657		0.1234	Not Supported
Interaction							
Hypothesis 2: The moderating role of firm privacy concern on the relationship between big data analytics capabilities and new product development process							
Hypothesis 2a: Firm privacy concern moderates, via innovation capabilities, the indirect effect of internal capabilities on new product development process							
Hypothesis 2b: Firm privacy concern moderates, via internal capabilities, the indirect effect of internal capabilities on new product development process							
Hypothesis 2c: Firm privacy concern moderates, via market knowledge breadth, the indirect effect of internal capabilities on new product development process							
Hypothesis 2a: Big data analytics capabilities x Firm privacy concern -> Innovation capabilities	-0.0357	0.0053	-6.6863	0.0000	-0.0462	-0.0252	Supported
Hypothesis 2b: Big data analytics capabilities x Firm privacy concern -> Internal capabilities	-0.0119	0.0314	-0.3786	0.7052	-0.0737	0.0499	Not Supported

Direct effect	Coeff	SE	t	P	LLCI	ULCI	Sig/Insig
Hypothesis 2c: Big data analytics capabilities x Firm privacy concern -> Market knowledge breadth	-0.0449	0.0328	-1.3680	0.1723	-0.1096	0.0197	Not Supported
Indirect effects	Effect	BootSE					
Hypothesis 1: (a) Innovation capabilities, (b) Internal capabilities, and (c) Market knowledge breadth mediate the effect of Big data analytics capabilities on New product development process							
Hypothesis 1a: Big data analytics capabilities -> Innovation capabilities-> New product development process	0.3392		0.1435		0.0587	0.6179	Supported
Hypothesis 2b: Big data analytics capabilities -> Internal capabilities -> New product development process	0.0205		0.0128		0.0004	0.0505	Supported
Hypothesis 2c: Big data analytics capabilities -> Market knowledge breadth -> New product development process	-0.0019		0.0086		-0.0226	0.0132	Not Supported
Control Variables							
Gender	0.0009	0.0346	0.0246	0.9804	-0.0671	0.0688	
Age	-0.0086	0.0170	-0.5035	0.6150	-0.0421	0.0250	
Education	-0.0065	0.0282	-0.2301	0.8181	-0.0620	0.0490	
Position	-0.0156	0.0157	-0.9928	0.3216	-0.0465	0.0153	
F-statistic	875.83						
R2	9510.						

Table 5: Results, Implications, and Practical Recommendations

Results	Implications for Business Managers	Implications for Policy Makers	Implications for Consumers	Practical Recommendations
Big data analytics capabilities significantly enhance innovation capabilities	Managers should invest in analytics to foster innovation and develop novel products	Develop policies that incentivize the use of big data analytics in innovation	Benefit from innovative and personalized products driven by data analytics Consumers might experience slower improvements in internal efficiencies without effective analytics integration	Build advanced analytics infrastructure and promote a culture of innovation within organizations
Big data analytics capabilities do not significantly influence internal capabilities	Internal capabilities require complementary strategies to leverage analytics effectively	Encourage cross-industry collaboration to share best practices for improving internal capabilities	Ensure diverse market perspectives are maintained in the products and services offered	Integrate analytics teams with operational processes to better support organizational goals
Big data analytics capabilities negatively impact market knowledge breadth	Over-reliance on analytics may reduce exploratory market learning	Support policies that balance analytics-driven insights with exploratory research efforts	Access to innovative products that better meet consumer needs	Combine data analytics with qualitative market research to improve market knowledge breadth
Innovation capabilities significantly mediate the relationship between big data analytics capabilities and new product development	Innovation capabilities are crucial for converting analytics insights into successful products	Promote funding for innovation ecosystems that align analytics capabilities with product development		Align data analytics strategies with product development objectives to enhance innovation outcomes

Results	Implications for Business Managers	Implications for Policy Makers	Implications for Consumers	Practical Recommendations
Internal capabilities significantly influence new product development	Strong internal capabilities improve product innovation and development efficiency	Create frameworks that encourage investment in building internal capabilities	Improved product development and delivery times for consumers	Strengthen internal processes through cross-functional teams and capacity-building initiatives
Firm privacy concern attenuates the relationship between big data analytics capabilities and innovation capabilities	Privacy concerns hinder analytics-driven innovation, requiring strategic compliance measures	Develop clear regulatory guidelines to balance privacy and innovation demands	Consumers gain confidence in data use while benefiting from innovation	Invest in privacy-preserving technologies and establish compliance-focused innovation strategies
Market knowledge breadth and privacy concerns do not significantly moderate other relationships	Market knowledge and privacy concerns may not significantly affect certain analytics-driven outcomes	Explore additional areas where privacy regulations and market factors may play a role in innovation outcomes	Potentially limited impact of these factors on the diversity of available products	Conduct context-specific research to identify when privacy and market factors are most influential



الموازنة بين تحليلات البيانات الضخمة والخصوصية في الابتكار: إطار لتطوير المنتجات الناجحة

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المستخلص:

تستكشف هذه الدراسة كيف تعزز قدرات تحليل البيانات الضخمة تطوير منتجات جديدة في مجال الرعاية الصحية، مع التركيز على الدور الحاسم لابتكار الخدمات في الاستفادة من هذه القدرات لدفع الحلول التي تركز على المريض مع إدارة مخاوف الخصوصية. في حين أن قدرات تحليل البيانات الضخمة يمكن أن تدفع الابتكار الطبي من خلال توفير رؤى حول نتائج المرضى واتجاهات المرض، فإن اللوائح الصارمة مثل اللائحة العامة لحماية البيانات تخلق مقايضات بين الابتكار القائم على البيانات والخصوصية. باستخدام بيانات من 324 متخصصاً في قطاع الرعاية الصحية في المملكة المتحدة، تبحث هذه الدراسة في كيفية توسط قدرات الابتكار والقدرات الداخلية واتساع المعرفة بالسوق بين قدرات تحليل البيانات الضخمة وعلاقة تطوير المنتجات الجديدة، مع اهتمام الشركة بالخصوصية الذي يخفف من هذه التأثيرات. تكشف النتائج أن قدرات تحليل البيانات الضخمة وحدها غير كافية لتطوير منتجات جديدة؛ فالقدرات التكميلية مطلوبة لتعظيم تأثيرها. علاوة على ذلك، فإن اهتمام الشركات بالخصوصية يحد بشكل كبير من تأثير قدرات تحليل البيانات الضخمة، مما يؤكد أهمية ممارسات البيانات المتوافقة مع الخصوصية. تساهم هذه الدراسة في الرؤية القائمة على الموارد من خلال تسليط الضوء على اعتماد قدرات تحليلات البيانات الضخمة على القدرات الأخرى وتقدم رؤى قابلة للتنفيذ لمديري الرعاية الصحية الذين يتعاملون مع الطلب على الخصوصية والابتكار..

الكلمات الرئيسية.

السلوك السياحي التحليلات العاطفية. البيانات الاصطناعية؛ عينة السيلكون. ماجستير في القانون؛ الذكاء الاصطناعي التوليدي (GenAI)، التعلم الآلي

