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Innovation Business Model: Adoption of Blockchain Technology and Big Data Analytics

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Abstract: Blockchain technology (BC) and big data analytics capability (BDAC) are two crucial emerging technologies that have attracted significant attention from businesses and academia. However, their combined effect on business model innovation (BMI), along with the moderating role of environmental uncertainty and the mediating influence of corporate entrepreneurship, remains underexplored. To fill this gap, the present study investigates the combined effects of BDAC and blockchain adoption on BMI and explores the mediating role of corporate entrepreneurship as well as the moderating effect of environmental uncertainty. Drawing on the dynamic capability view (DCV) and the related literature, this study investigates these relationships using a conceptual framework hypothesising that (1) BDAC and blockchain adoption affect BMI through corporate entrepreneurship and (2) environmental uncertainty moderates these relationships. Consistent with the main theoretical arguments, our results, based on a sample of 284 employees working in Australian firms, indicate direct and indirect impacts of both BDAC and blockchain adoption on BMI. Corporate entrepreneurship was found to play a partial mediating role in the relationship between the two technologies, while BMI and environmental uncertainty were found to be significant moderators. These findings have significant theoretical and practical implications for companies striving to innovate their BMI. The results suggest that the synergistic effects of BDAC and blockchain technologies together create entrepreneurial activities and strategies to generate value, thus enabling BMI. Furthermore, the mediating role of corporate entrepreneurship and the moderating effect of environmental uncertainty have important theoretical implications for innovative BMI and management. As such, this study highlights the potential of BDAC and blockchain technologies to drive sustainable business practices, offering insights into how these technologies can contribute to economic, social, and environmental sustainability through innovative business models.

Keywords: blockchain adoption; big data analytics capabilities; corporate entrepreneurship; environmental uncertainty; dynamic capabilities; sustainable business models

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1. Introduction

Blockchain and big data pose significant challenges to the boundaries of existing industries such as banking, cyber security, supply chains, and healthcare, and data analytics holds transformative potential for business. In the last few years, big data and blockchain have been seen as opportunities for innovation [1]. Importantly, scholars argue that when combined, this technology can help organisations exploit their capabilities to innovate their business models [2–4], such as improving the understanding and analysis of their customers and operations, and generating new revenue streams due to big data analytics [5]. On the other hand, BMI can be significantly disrupted by BC, which allows for new decentralised business models that offer greater efficiency, security, and transparency [6].

Amid turbulent market changes, forward-looking businesses have been relentlessly searching for innovative business models to take advantage of upcoming technologies. Sebastian et al. [7] reported that digital business transformation makes companies future-ready and increases average net revenues by 16%. Other studies have reported that digitalisation could result in an increase of EUR 1.25 trillion in the industrial value of Europe [8] and AUD 315 billion in economic opportunities for Australia [9]. The digital business model is of utmost importance to them to stay competitive, make their operations more efficient, increase trust and security, and identify new revenue streams [10,11].

It is also likely that blockchain and big data analytics open up new spaces for innovative business model design and work organisation that offer great potential for growth and success in this ever-changing business landscape [6]. In practice, however, adopting those technologies for innovative business model design is not straightforward, especially when they are still in the early stages of adoption, and hence, there are barriers to adoption at the level of business models. For instance, blockchain can undermine organisations whose business models have a third party as an intermediary to ensure trust and verification [12,13]. Similarly, big data analytics can be constrained by a variety of factors, such as cost, culture, regulations, insufficient IT resources, and governance frameworks [14].

Although they have a lot of barriers, these two emerging technologies are increasingly considered in the academic literature as having the potential to transform the dynamics of business model innovation [3,6,15–18]. Following the DCV, the newest emerging technologies will impact business model innovation by intensifying the entrepreneurial efforts of organisations [19]. According to the DCV, organisations working in fast and uncertain environments are trying to develop new solutions by leveraging their internal and external IT capabilities to innovate their business processes and create new services and products [20].

Several scholars have thoroughly studied the role of digitisation in bringing about new entrepreneurship and business model innovation [21–24]. Mainly, scholars have recently explored the roles of big data analytics and blockchain on business models independently [3,25]; however, the combined effects of these technologies on business model innovation have not been investigated sufficiently and based on anecdotal and proposed solutions and frameworks [26]. In other words, figuring out the causal relationships between the combined impact of big data analytics and BC on business model innovation holds importance since it can serve as a stepping stone towards a better understanding of how these technologies can be leveraged in conjunction with each other to achieve business objectives, guide decision-making better, provide insights into this novel combination, and take this decision-making process in a direction that is evidence-based [27,28].

In summary, examining the advantages of the mutual application of big data analytical functions in complex relational databases and blockchain in companies is a research field that could entertain challenging issues and produce many benefits for businesses. Moreover, BDAC and blockchain adoption in the BM configuration are mutually difficult to measure and identify because there are other contingent variables that can affect this relationship [3,25]. For example, the entrepreneurial spirit and innovative behaviour of a company are one of the most important aspects in the adoption and use of new digital technology in developing new services, products, and BM [29–31].

In this sense, corporate entrepreneurship had a significant mediating role in the adoption and implementation of digital technologies [32,33]. Moreover, the adoption and use of digital technologies also differ depending on the external environment of the company. Companies that function in an environment of uncertainty are more likely to adopt and use new technologies than companies that function in an environment of stability [34–36].

After the above-mentioned discussions, exploring the leverage of BMI using BDAC and blockchain adoption warrants more empirical examination to truly understand the role of BC in assisting companies in achieving BMI via enhancing their BDAC. A more nuanced model that captures the reverse relationship among intervening variables, such as corporate entrepreneurship and environmental uncertainty, is needed to assess their combined effects. Consequently, a more in-depth investigation is warranted to uncover the complex interplay of these effects. The leveraging literature that highlights the potential of BDAC and BC in firms' ability to generate value-added and innovative business models [3,4,37,38] offers an opportunity to address a significant void in the current body of knowledge.

Following other studies that argue that these technologies can be deployed in dynamic and turbulent markets, for this study, we use the dynamic capability view (DCV) as a conceptual lens [39,40]. Additionally, taking into consideration that data-driven BMI often requires profound changes in business practices (e.g., because of the new standards a company needs to implement and the new processes or new capabilities it needs to acquire) [41], we focus on the role of corporate entrepreneurship as a mediator in the link between BDAC and BC. This integration into DCV is possible because corporate entrepreneurship can be considered a higher-order capability that leverages on BDAC and BC. Thus, according to the DCV, the use of these technologies is determined by environmental dynamics and uncertainty [36,42]. The contextualisation of these technologies and BMI systems with environmental uncertainty helps to bring out the whole picture.

This study enriches the existing literature on the positive influence of dynamic capabilities on company value by investigating the innovative potential of big data analytics and blockchain in business contexts, focusing on the relationship between BDAC and blockchain adoption (independent variables) and BMI as dependent variables. Second, by scrutinising the mediating impact of corporate entrepreneurship, we substantiate how companies strategically leverage big data analytics and blockchain to cultivate an entrepreneurial and innovative mindset, thus facilitating the revitalisation of their business models. Finally, by examining the moderating role of environmental uncertainty, we validate how companies navigating uncertain and dynamic markets are prompted to deploy digital technologies.

Furthermore, the adoption of BDAC and blockchain technologies has significant implications for sustainable business practices and long-term organisational viability. These technologies can contribute to all three pillars of sustainability: economic, environmental, and social. From an economic perspective, BDAC and blockchain can enhance resource efficiency and create more sustainable business models [43]. Environmentally, these technologies enable better tracking and management of resource use and emissions, supporting more eco-friendly practices [44]. Socially, blockchain's transparency and BDAC's insights can foster trust and ethical business conduct [45]. By integrating sustainability considerations into our analysis of BDAC and blockchain's impact on BMI, this study also contributes to the growing body of research on technology-driven sustainable business transformation [46].

The next section provides a theoretical background, which formulates the literature review, following which we then address the methodology, outlining the data collection process, the measurements, the non-response bias process, and the analysis process. We present how the analyses of the data were performed using Smart PLS, followed by a descriptive statistic measure of the sample. In our final section, we discuss the results of our study which draws on limitations of the study, theoretical and managerial implications and conclude with recommendations.

2. Theoretical Background and Literature

2.1. Dynamic Capability View

Dynamic capabilities view (DCV) refers to a firm's powers to integrate, build, and reconfigure internal and external skills to address rapidly changing environments. These are the abilities required for both sustaining success and expanding the market [47]. Further, Teece [48] states that a company's DCV determines its business model design proficiency. For instance, a number of scholars have recently illustrated how this perspective can be applied to the field of information technology [49–52]. Having access to digital information technology (IT) is of great value to companies operating in dynamic and turbulent environments that are subject to rapid change. Many studies have relied on the concept of

DCs to analyse how ICT can create firm value [48,52–54] and to create new and disruptive business models [48,55].

DCV has been extensively utilised to elucidate the contributions of information and communications technology (ICT) to company value [48,52–54] and new business models [48,55]. Several prior studies demonstrated the applicability of DCV in the field of information systems [49–52]. According to Wade and Hulland [56], information systems (IS) have many characteristics related to DCV due to the significance of information technology (IT) for companies to survive in a dynamic, rapidly changing environment. A company's business model design proficiency depends on its DCV Teece [48]. A business model influences the feasibility of its strategies through its influence on the design. Teece et al. [57] described DCV as the ability of a company to integrate, develop, and reconfigure internal and external competencies to cope with the dynamically changing environment. Through DCV, companies can effectively create unique organisational competencies, practices, and strategies for business success and expansion [47]. Prescott [58] elaborated that the inability of a company to adapt its intangible and tangible resources according to the needs of its external environment would put its competitive advantage and performance at risk over time.

According to the theory of innovation, the introduction of successful innovations and innovative management of resources help companies to gain competitive advantage and economic gains [59]. A successful company adopts a continuous learning process [60] and demonstrates the capacity to acquire new knowledge [61] and entrepreneurial mindset and attitude [62], which improves its adaptability in a dynamic and uncertain environment [57], resulting in better decision making [36]. This perspective is deemed to be particularly relevant to research on big data analytics and blockchain adoption and their impact on BMI due to the significance of DCV for companies to effectively innovate and respond to the external environmental changes [57]. Through the mechanism of corporate entrepreneurship, a company develops its DCV [33]. Considering that, it is deemed plausible that corporate entrepreneurship mediates the relationship of BDAC and BC adoption with BMI. Meanwhile, [63] identified environmental uncertainty as a moderator in the relationship of BDAC and blockchain adoption with BMI.

The above discussion was deemed relevant to the current study. There are various ways involving IT and innovation for companies to realise their strategic goals and action plans, such as customer relationships, operational excellence, new products and services [64], new business models, and added value [65]. A company with proper planning and management of these opportunities can enhance its performance and achieves a successful BMI. The use of DCV is deemed fitting in determining the impact of BDAC and blockchain adoption on BMI, as well as the mediating effect of corporate entrepreneurship and the moderating effect of environmental uncertainty. In other words, companies can improve the effectiveness of its response towards environmental uncertainty and promote BMI by leveraging DCV and adopting advanced technologies, such as big data analytics and blockchain.

2.2. Business Model Innovation

Business model innovation (BMI) allows businesses to innovate their revenue models to remain relevant to their current and potential customers. BMI involves creating new business models or significantly improving existing ones ('changing the game' instead of 'playing the game') through the development of new products, markets, or distribution channels [66]. According to the literature, there are three key dimensions for bringing innovation to businesses: value creation, proposition, and capture [67]. The value proposition dimension defines goods and services in terms of their availability, nature, and quality. The value-capture component represents how business value propositions can be translated into profits over time. Significant changes to the core value dimensions are required. To achieve BMI, at least one of the core value dimensions needs to be changed, and this requires a new value to be created, proposed, and/or captured [68].

In order to create value for customers, businesses must gain a useful appreciation of their customers, competitors, and markets so as to develop data-driven value propositions or market-oriented offerings that lead to improved profitability and prosperity. Market-oriented offerings may be generated via the use of BC [25]. Marikyan, Papagiannidis, Rana and Ranjan [4] point out that BC holds great promise in how businesses operate; in how we engage with customers; and in generating different funding mechanisms such as cryptocurrencies, crowdfunding, and other alternate financing routes. Blockchain can help businesses to improve their transaction efficiency, transparency, and customer service. As a result, businesses will benefit from increased competitiveness in the marketplace.

Further, BDACs represent how big data instil strategic intelligence in the organisation. As the pace of market development becomes very fast, organisations' ability to sense new multifaceted data and use it strategically will instil dynamic organisational capabilities, or the ability to change and adapt the way firms are organised to outperform existing competitors and open new market opportunities. As such, BDACs require the constant renewal of organisational capabilities to stay competitive and take advantage of new market opportunities. To achieve innovative business models and competitive advantage in an organisation, a culture that commands and utilises resources like data scientists and IT specialists to explore new possibilities of the potential value of new and innovative BDACs must exist [69]. BDACs can be seen as lower-order dynamic capabilities that directly impact BMI or as a capacity that generates higher-order dynamic capabilities. BDAC investments, therefore, are critical to an organisational competitive advantage.

2.3. Blockchain Technology (BC)

Blockchain technology (BC) was first introduced back in 2008 when anonymous individuals or groups created Bitcoin using the pseudonym 'Satoshi Nakamoto' [70]. Since then, various industries, such as finance, food industry, healthcare, and supply chain management, have adopted blockchain [71–73].

Accordingly, Deepa, Pham, Nguyen, Bhattacharya, Prabadevi, Gadekallu, Maddikunta, Fang and Pathirana [6] defined BC as a distributed ledger system that enables secure, transparent, and tamper-proof record-keeping. In a blockchain system, each transaction must be verified and recorded by a computer network, instead of a central authority [74]. This decentralised approach ensures no single point of failure, which lowers the susceptibility of BC to fraud and tampering [75].

This highlights the significance of blockchain, its use to make records secure and safe, tamper-proof, and transparent. Studies by Deepa, Pham, Nguyen, Bhattacharya, Prabadevi, Gadekallu, Maddikunta, Fang and Pathirana [6] and McGhin, Choo, Liu and He [71] asserted that blockchain will emerge as one of the most reliable frameworks for record-keeping in the modern world. Queiroz, Telles and Bonilla [72] opines that companies need to adapt and adjust their structures according to the changing business scenario. It is important to become fast and respond quickly to challenging situations.

Digital transformation requires an organisation to acquire the new competencies required for the restructuring of the organisation and for the redesign of the business model. The adoption of blockchain can transform a company's performance in critical dimensions, such as security, transparency, cost, and time, leading to overall efficiency. Apart from delivering these impacts, adopting blockchain also nurtures a range of new DCVs, such as smart contracting, an integral part of the blockchain that makes it a critical capability for firms aspiring to thrive in the disruptive business environment where stability is difficult to sustain [6].

2.4. Big Data Analytics Capabilities (BDACs)

Big data analytics capabilities (BDAC) refers to a process of analysing large datasets to identify unique patterns, trends, and insights for various decisions in business, such as marketing and product development [76]. There are several techniques involved, such as predictive analytics, machine learning, and text mining [77]. Based on historical data, predictive analytics predicts the future outcomes [78]. Meanwhile, machine learning algorithms automatically identify data patterns [79]. Text mining extracts valuable information from large datasets [80]. In short, businesses gain valuable information for more informed decisions through big data analytics.

Developing the ability to make use of big data, or in other words, BDAC, can help companies to gain strategic insights that cannot be replicated by competitors, which can facilitate their continuous learning and reapplication of routines of examining new multifaceted data and increase their competitiveness over time [81]. Studies have identified BDAC as an enabler of both dynamic organisational capabilities [82] and DCV [83]. It is necessary for companies to continuously improve both of these capabilities in order to gain competitive advantage and valuable market opportunities [84]. Hence, the development of BDAC is critical for a company in terms of BMI and competitive advantage [85]. Companies need to create and maintain the culture of engaging organisational resources, such as data scientists and IT specialists, in order to explore various potential opportunities for BDAC [69]. Companies should make effort to recognise the use of BDAC to enhance their BMI [86]. Considering these theoretical evidence and findings of prior studies [87] and viewpoints of Ciampi, Demi, Magrini, Marzi and Papa [3], BDAC can be viewed as lower-order DCV with direct contribution to BMI or towards the creation of higher-order DCV.

2.5. Corporate Entrepreneurship

Another important component of the new business model is corporate entrepreneurship, which has gained importance in recent years. Research by Urbano et al. [88] shows its significance for the economy and for companies to survive the competition. Corporate entrepreneurship is defined as a company's internal process of creating new businesses or making a breakthrough for existing ones, leading to innovation and contributing to permanent competitiveness [88]. Corporate entrepreneurship is also called intrapreneurship, collective entrepreneurship, corporate venturing, or internal entrepreneurship.

Innovation, especially product and process innovation, comes from the corporate entrepreneurial function [89]. Companies sense changes in the market, learn from them, experiment with them, and then engage in the reconfiguration of resources and capabilities to innovate based on the peculiarities of these characteristics [48]. Dynamic capabilities that are data-driven are crucial to corporate entrepreneurship, allowing organisations to recognise and exploit opportunities and adapt to environmental changes.

Corporate entrepreneurship has been identified in the digital economy as a valuable source of knowledge to utilise new technologies for innovation [90]. Information technologies could play a pivotal role in strengthening corporate entrepreneurship by facilitating the acquisition of knowledge, enhancing efficiency in discovering new opportunities for innovation, and increasing responsiveness to dynamic changes in the environment. By leveraging the blockchain and big data analytics capabilities, a firm can lead the change and create market value [5]. Ultimately, we argue that corporate entrepreneurship, combined with the capabilities of blockchain and big data analytics, provides organisations with the means to produce meaningful business model innovation and stay ahead of competition.

2.6. Environmental Uncertainty

Environmental uncertainty, on the other hand, describes a situation where information about the environment is hard to discriminate between essential and irrelevant data, resulting in a situation where the organisation lacks adequate information to make predictions [91]. In recent years, DCVs have been increasingly used as a lens through which we can examine organisations' response to an ever-changing environment and can be defined as a firm's ability to identify and appropriately exploit changes and opportunities in its environment or as a company's ability to identify and respond to new opportunities and threats in a timely and effective manner [92].

Gifford et al. [93] remarked that dynamically uncertain environments, such as the COVID-19 crisis, could further emphasise the value-added of DCV as a market-context enforcement. While resource-based view theory addresses the 'what' and the 'how' of DCV, the dynamic capabilities framework is centred on the 'when'—it focuses on the ability of an organisation to sense, secure, and transform in an external environment that is changing over time. According to Naldi et al. [94], sense-making or seizing capabilities are related to a company's innovative performance, and such capabilities are crucial for enterprises to stay aloft and ahead in the prevailing challenging market climate. With advanced sense-making skills and accelerated-response capabilities, a firm is capable of perceiving the menaces and emerging opportunities in the market in a timelier manner.

In a highly uncertain market environment, a company's organizational resilience, including adaptability and flexibility, before and after the adoption of emerging technologies such as blockchain and big data analytics, is crucial [95]. These technologies provide a high level of certainty in decision-making, enabling companies to achieve superior agility, flexibility, and innovation in a dynamic business environment. Furthermore, blockchain and big data analytics assist businesses in managing changing marketplace uncertainties [34].

3. Hypothesis Development

Our main aim is to devise hypotheses that express expected relationships or patterns in a way that can be tested—based on theories, empirical observations, or 'gaps' in our current understanding of a phenomenon. Such hypotheses are 'testable' propositions that help us to design empirical investigations that contribute to making that field of knowledge systematic in its organisation.

3.1. Business Model Innovation and Big Data Analytics

Business model innovation is a common practice and theoretical field in entrepreneurial activity and entrepreneurial research. It is the strategy that firms use to create and capture value for themselves and their customers [96]. Big data analytics and other high technology could be a critical element of BMI in most companies. A number of worldwide studies have demonstrated that big data analytics can build new capabilities for firms to innovate their business model and update or create new ones [3,97]. Big data analytics can collect customer needs and offer products of higher quality than before. They may find new pricing models that bring more value to customers than the traditional way through cheap prices. The companies may have more opportunities to improve their competitive position [5]. Ciampi, Demi, Magrini, Marzi and Papa [3] state that businesses that learn to use big data analytics are more likely to be able to propose new value propositions when innovating. Moreover, big data analytics can help businesses increase their competitive advantage by providing them with the right information to make informed decisions. In this sense, Wang et al. [98] found that big data analytics can optimise operations and reduce costs.

H1: *BDAC has a positive impact on business model innovation.*

3.2. Blockchain Adoption and Business Model Innovation

Massaro [99] highlights that digitalisation often means a transition to a digital centre, a DCV that must constantly adapt to new technology. For instance BC, help companies innovate in multiple industries and disrupt the status quo. As already mentioned, BC is considered a promising technology for creating value and disrupting established business models in multiple industries. It also offers an opportunity to construct new business models and generate value among actors (organisations, people, and technology) in ways that did not exist before. For instance, Marikyan, Papagiannidis, Rana and Ranjan [4] asserted a positive relationship between BC adoption and BMI. Meanwhile, Morkunas, Paschen and Boon [16] analysed how BC impacts the business model canvas using real-world examples. Similarly, Marikyan, Papagiannidis, Rana and Ranjan [4] found that BC has the potential to innovate existing business models or create novel ones. These findings align with Schlecht, Schneider and Buchwald [13] prediction that BC will create value in 15 years. That is why numerous companies have adopted BC in numerous ways and in numerous business models.

H2: *Blockchain adoption has a positive impact on business model innovation*.

3.3. Big Data Analytics Capabilities and Corporate Entrepreneurship

Information technology capabilities include those that enable deployment and are mobilised in combination with other resources [100]. Through these, businesses may reduce costs, increase profits, and achieve other performance metrics that are superior to their competitors [101]. The literature finds that big data analytics is an example of IT capabilities that enhance corporate entrepreneurship [102]. For example, Chen et al. [103] found that IT capabilities improve corporate entrepreneurship. They assert that IT capabilities will form the foundation for engaging in new ventures, introducing cutting-edge products, and updating business processes and models across the company. Recently, Ciampi, Demi, Magrini, Marzi and Papa [3] concluded that BDAC significantly impacts entrepreneurial orientation, which can be assimilated into corporate entrepreneurship. Therefore, we predict the following:

H3a: *BDAC has a positive impact on corporate entrepreneurship*.

Corporate entrepreneurship involves innovation in products and processes, leading to the development of new businesses within existing companies [104]. Companies use various business models to exercise entrepreneurship by focusing on satisfying market demands and describing their relationships. Rodríguez-Peña [105] emphasises the importance of innovation in corporate entrepreneurship. Corporate entrepreneurship encourages outside-the-box thinking, proactiveness, and risk-taking, leading to new and innovative business models. It also helps companies become more agile and responsive to market changes, which is essential for a successful BMI [106]. Companies that encourage corporate entrepreneurship are more likely to innovate their business models. The relationship between corporate entrepreneurship and BMI has been demonstrated in several studies, with prominent corporate entrepreneur attributes being positively associated with the adoption of disruptive business models. Entrepreneurial orientation directly affects the development of business models and their components [3].

H3b: *Corporate entrepreneurship has a positive impact on business model innovation*.

In Hypothesis 1, we assume that BDAC positively and directly influences BMI. In Hypotheses 3a and 3b, we propose that BDAC can positively and directly influence corporate entrepreneurship, while corporate entrepreneurship can positively and directly influence BMI. Hence, direct and indirect relationships may exist between BDAC and BMI, and corporate entrepreneurship may act as a mediator. An invaluable aspect of corporate entrepreneurship is its perspective on how IT capabilities translate into firm-level results [107]. Businesses that spend a great deal of time developing and improving products by conducting new market research and rethinking processes can achieve greater success in product development [100]. By effectively utilising their information technologies, companies can attain high levels of corporate entrepreneurship activities [108], suggesting that the intermediary function of corporate entrepreneurship activities may influence how well companies' IT capabilities support product innovation [103]. Several related studies have proven that corporate entrepreneurship plays a crucial role as a mediator between big data analytics, such as IT capability and BMI. Chen, Wang, Nevo, Benitez-Amado and Kou [103] discovered that corporate entrepreneurship is a mediator between new IT capabilities and product innovation. Ciampi, Demi, Magrini, Marzi and Papa [3] confirmed that a company should have an entrepreneurial orientation attitude as a mediator between BDAC and BMI. Finally, Yunis, Tarhini and Kassar [32] assert that ICT-based innovations enhance organisational performance when innovative strategies and behaviours (i.e., corporate entrepreneurship) are used to exploit the opportunities they offer.

H3c: *Corporate entrepreneurship mediates the positive relationship between BDAC and business model innovation.*

3.4. Blockchain and Corporate Entrepreneurship

Blockchain technology, as described by Deepa, Pham, Nguyen, Bhattacharya, Prabadevi, Gadekallu, Maddikunta, Fang and Pathirana [6], is a decentralised technology that fosters innovation and creativity by eliminating the need for centralised authority. This technology has been proven to revitalise company processes and enhance resource efficiency and data exchange. It has also been shown to create new products and services [109] and adjust existing products based on customer preferences [4]. In the digital era, corporate entrepreneurship has had a significant impact on product innovation [89]. BC has capabilities similar to big data analytics and even enhances its functionality, enabling it to scan and sense market opportunities by accumulating secure and relevant data. This is considered valuable for corporate entrepreneurship [89]. Therefore, we anticipate a positive relationship between blockchain adoption and corporate entrepreneurship.

H4a: *Blockchain adoption has a positive impact on corporate entrepreneurship.*

In accordance with Hypothesis H3c, blockchain is viewed as an emerging technology, similar to big data analytics. According to this hypothesis, corporate entrepreneurship can serve as a mediator between blockchain adoption and BMI.

A company can enhance the speed and accuracy of resource allocation to new initiatives and tasks by improving cycle times, developing cross-functional procedures, and collaborating to create new products by improving its IT capabilities [110]. For instance, Chalmers et al. [111] admitted that blockchain could be a powerful tool for introducing new value propositions and business ventures. This can be achieved by entrepreneurial agents within a company who can sense external opportunities and have a creative mindset.

In the absence of existing studies explaining the mediating effect of corporate entrepreneurship between blockchain technology adoption and business model innovation (BMI), we hypothesize that while blockchain is an important information technology that assists start-ups and existing firms in realizing new ventures and achieving organizational goals, the operational and processual tasks required to initiate and execute new ventures, reshape and improve business processes, create new products, and consequently generate innovative business models may be central to blockchain technology adoption within organizations [24].

H4b: *Corporate entrepreneurship mediates the positive relationship between blockchain adoption and business model innovation.*

3.5. The Moderating Role of Environmental Uncertainty

Environmental uncertainty, which stems from rapid and significant changes in the environment, is a challenge for organisations [112]. Santos-Arteaga et al. [113] shed light on the importance of drawing from credible information sources to overcome environmental uncertainty. In turn, Gong and Ribiere [114] stress the importance of changing business models in uncertain environments, such as rapid changes in the marketplace or disruptive technologies. Consequently, Darvishmotevali, Altinay and Köseoglu [112] asserted the need for organisations to adapt their strategies to mitigate this uncertainty.

Furthermore, Gangwar et al. [115] propose that big data analytics can reduce environmental uncertainty and facilitate making better decisions, while Ciacci and Penco [107] argue that this technology is particularly useful to organisations to take advantage of opportunities during uncertain times. Dai and Liang [36] also argue that when market demand is low, the stimulating effect of big data analytics technical skills on BMI becomes weaker, and resource integration is less dependent on these skills. Generally speaking, most researchers argue that without adopting big data analytics, companies will not only be driven to irrelevance but will also be less competitive. Leung et al. [116] highlight its ability to reduce environmental uncertainty, while Saberi, Kouhizadeh, Sarkis and Shen [44] argue that uncertainty in supply chains can be mitigated by BC; hence, more organisations are adopting it. Overall, a high level of environmental uncertainty would affect the relationship between IT adoption and BMI. BDAC and blockchain are innovative technological solutions, and their influence on firm performance is largely contingent on the level of environmental uncertainty.

H5: *Environmental uncertainty moderates the relationship between BDAC and business model innovation.*

H6: *Environmental uncertainty moderates the relationship between blockchain adoption and business model innovation.*

Following the development of hypotheses, a conceptual model (Figure 1) was developed based on a review of the related literature with respect to the DCV. The model depicted the relationship of leveraging BDAC and adopting blockchain with BMI. Furthermore, this study postulated the influence of entrepreneurial activities and drive to exploit opportunities and engagement with these technologies on BMI under the condition of environmental uncertainty.

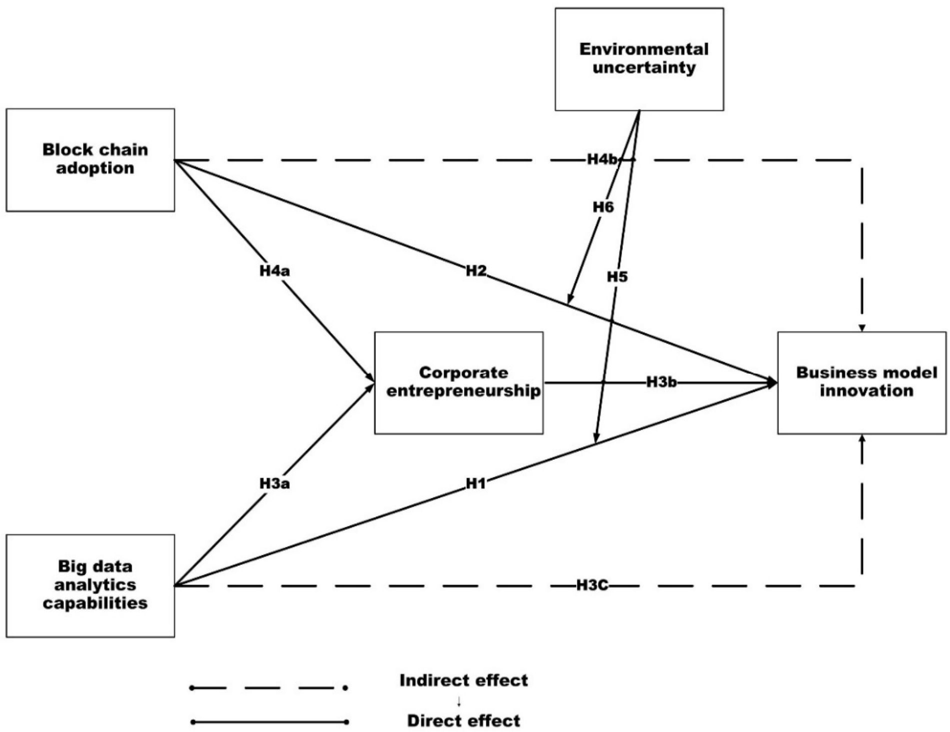

Figure 1. Conceptual model of this study.

4. Methodology

Adopting a positivist research approach, this study relies on causal relationships and quantitative data measurements as valid indicators of reality. Survey measures were employed within the context of this positivist methodology to ascertain the dimensions of BDAC and blockchain adoption essential for achieving the research objectives. Initially, a thorough review of the literature was conducted to identify the dimensions of BDAC and blockchain adoption; their impact on BMI; and the mediating role of corporate entrepreneurship in the relationships among BMI, BDAC, and BC adoption. Furthermore, this investigation extends to the examination of these relationships within the framework of environmental uncertainty. The conceptual model, grounded in the DCV theory, was developed, and the hypothesised relationships were rigorously validated using structural equation modelling (SEM), specifically based on partial least squares (PLSs).

4.1. Data Collection

We employed an online questionnaire and a cross-sectional data collection strategy targeting managers and directors of Australian companies in the construction, manufacturing, trade, and financial sectors to test our hypotheses empirically. This study employed convenience sampling to select respondents from Australian firms. In order to ensure the validity of the data, we ensured that the respondents had a solid understanding of the variables chosen from among all the constructs included in the conceptual framework. This survey was conducted after a list of possible target populations was finalised. After confirmation, a questionnaire was sent to the participants. The option of conducting surveys both onsite and online was also considered. Furthermore, most of the data were collected online through an electronic survey. Managers, owners, and CEOs should respond to the questionnaire as they possess sufficient knowledge about their company and the strategies they will pursue in the future. However, respondents were instructed to ask other employees at their companies about the facts they were unaware of in order to ensure a collective response. Based on the reality that Australian companies are increasingly adopting and applying these new technologies to reinvigorate their businesses and increasing interest in entrepreneurial and innovation activities, they were selected to address the research objective [117,118]. Therefore, these businesses are good research targets for examining the studied variables. Participants in the study must have adopted BDAC and blockchain in their company or have plans to adopt them according to the invitation letter and explanation at the start of the survey.

Data collection was conducted over a 3-month period. Out of 1000 questionnaires, a total of 287 fully completed responses were collected, representing a response rate of 28.7%. Based on the number of questions, 3 of these were dropped because the compilation time was less than the bare minimum required to provide satisfactory answers. In total, 284 genuine respondents were included in the final sample.

According to the data collected statistics (see Table 1), 81.3% of respondents were male and 19.7% were female. Among the respondents, 43.3% had undergraduate degrees, 28.7% had postgraduate degrees, and 27.9% had diploma degrees. As for the industries, the majority of respondents were from the retail sector (21.1%), followed by financial services (15.5%), technology (11.6%), construction (7.8%), ICT (5.1%), and communication (5.6%), while the oil and gas industry (5.3%) ranked last. Other sectors represented 27.8% of respondents. In terms of their positions, the majority were heads of department at the senior level (46.8), followed by the general manager and CEO (30.8), and owners (22.4). According to the survey, 42.3% of the companies were medium-sized, 37.3% were large, 16.2% were small, and 4.2% were microsized. As a final note, most respondents had 5–10 years of experience in big data (62%), 21.1% had 1–5 years of experience, 14.8% had over 10 years, and only 2.1 had less than one year of experience.

Table 1. Respondents' demographics.

	Description	Frequency	Percentage
Gender (out of 284)	Male	231	81.3
	Female	53	18.7
Level of education	Diploma	69	27.9
	Bachelor's degree	107	43.3
	Postgraduate	71	28.7

Table 1. *Cont.*

	Description	Frequency	Percentage
Industry	Construction	22	7.8
	Financial	44	15.5
	Retail	60	21.1
	Tourism	15	5.3
	Technology	33	11.6
	ICT and communications	16	5.6
	Oil and gas	18	5.3
	Others (services, shipping, transportation, etc.)	76	27.8
Position in organisation	General manager or CEO	102	30.8
	Head of the department	155	46.8
	Owner	74	22.4
Number of employees in a company	<10	12	4.2
	10–50	46	16.2
	51–249	120	42.3
	>250	106	37.3
Years of experience in big data	<1 year	6	2.1
	1–5 years	60	21.1
	5–10 years	176	62
	>10 years	42	14.8

4.2. Measures

An earlier published multi-item scale with favourable psychometric properties was used in this study. Each construct was scored on a 5-point Likert scale (strongly disagree/strongly agree). Regarding BDAC, Mikalef, Boura, Lekakos and Krogstie [69] depict it as a 25-item formative third-order construct. Intangible resources (7 items), human skills (8 items), and tangible resources (10 items) made up BDAC's second-order formative constructs. Data, technology, and basic resources comprise the three first-order formative constructs of tangible resources. The human skills construct consists of four items in the technical skills category and four in the managerial skills category. Data-driven culture (3 items) and intensity of organisational learning (4 items) make up the intangible resource construct. With respect to blockchain adoption, a first-order reflective 3-item scale developed by Fosso Wamba and Guthrie [39] was used in this study. In turn, we measured corporate entrepreneurship using a validated 6-items scale developed by Zahra [119]. In turn, BMI was measured using a reflective 5-item scale from Asemokha et al. [120], whereas environmental uncertainty adopted a 4-item valid scale from Haarhaus and Liening [121].

4.3. Non-Response Bias

We performed a so-called successive wave analysis to detect possible non-response bias [122], where late respondents in one wave were instead treated as non-respondents in the following wave. It turned out that there was no difference between the answers given by late versus early respondents ($p > 0.10$). Hence, we can rule out a non-response bias [123].

4.4. Analysis and Results

To investigate the research model via a new statistical technique, it was established that structural equation modelling (SEM), which can calculate multiple paths of a complex research model [124], would be used. In the measurement model of structural equation modelling, the reliability of the research instrument and indicators was tested, and the validity was confirmed in the section below as a measurement model.

4.5. Measurement Model

According to the constructs' nature (reflective or formative), different validation criteria were adopted for our model. Concretely, we examined the convergent validity, discriminant validity, internal consistency, and composite reliability of the reflective constructs (first-order constructs: BDAC, blockchain adoption, corporate entrepreneurship, and BMI). Specifically, convergent validity was tested through the index of average variance extracted (AVE). After examining the data, the lowest value observed was 0.542, which was higher than the threshold of 0.50.

The discriminant validity of the reflective constructs was evaluated through three approaches. First, we ensured that the highest quadratic correlation between each reflective construct and any other reflective construct was higher than its AVE value (Fornell–Larcker criteria). As a second step, it was necessary to check whether the outer loadings were greater than the cross-loadings for each item [125]. Thirdly, by using Cronbach's alpha index, we tested the internal consistency of the reflective constructs and found them to be higher than 0.6, with the lowest observed value outside of this range being 0.619. Finally, the reflective constructs' composite reliability values, which we calculated in the last stage, verified their validity when contrasted with Nunnally's minimum requirement of 0.70.

Each item was quantified based on its saturation level in relation to the outer loading of the corresponding construct in order to assess the reliability of the indicators for all constructs (both reflective and formative). In each case, the value exceeds 0.70. These results indicate that both our reflective constructs and the construct indicators are valid.

Regarding formative constructs, we began by determining how crucial the weights are. We found that there is a positive and highly significant weight for all items in all first-order constructs. Each second-order construct and third-order construct (BDAC) shows a positive and highly significant weight. Subsequently, we calculated Edwards' adequacy coefficient (R^2a), as suggested by MacKenzie et al. [126]. The R^2a values were higher than 0.50 for all formative constructs of the first, second, and third orders. To determine whether multicollinearity was present between the formative construct indicators and between the first- and second-order formative construct indicators, we calculated variance inflation factors (VIFs). It was confirmed that there was no multicollinearity when all values were below 10.

To further address potential concerns about multicollinearity, we conducted a detailed analysis of the VIF for all predictor variables in our model. The VIF values for all variables were well below the commonly accepted threshold of 10, with the highest observed VIF being substantially lower than this cutoff. These results provide additional confirmation that multicollinearity is not a significant concern in our model, lending further credibility to our findings. The low VIF values indicate that our predictor variables are sufficiently independent of each other, allowing for reliable estimation of their individual effects on the outcome variables and strengthening our confidence in the stability and reliability of our regression coefficients and hypothesis tests. The results of our analysis for convergent validity, discriminant validity, internal consistency, and composite reliability of the reflective constructs are presented in Table 2.

Table 2. Convergent validity, discriminant validity, internal consistency, and composite reliability of the reflective constructs.

Factor	Item	Outer Loading	Cronbach's Alpha	Composite Reliability	AVE
BR	BR1	0.845	0.679	0.826	0.704
	BR2	0.833			

Table 2. *Cont.*

Factor	Item	Outer Loading	Cronbach's Alpha	Composite Reliability	AVE
CENTRP	CENTRP1	0.788	0.760	0.842	0.523
	CENTRP2	0.835			
	CENTRP3	0.751			
	CENTRP4	0.702			
DD	DD1	0.881	0.712	0.841	0.643
	DD2	0.857			
	DD3	0.646			
D	D1	0.733	0.731	0.848	0.651
	D2	0.824			
	D3	0.858			
T	T1	0.781	0.737	0.835	0.560
	T2	0.762			
	T3	0.704			
	T4	0.744			
MS	MS1	0.831	0.664	0.814	0.597
	MS2	0.839			
	MS3	0.631			
OLI	OLI1	0.849	0.864	0.907	0.709
	OLI2	0.871			
	OLI3	0.863			
	OLI4	0.783			
TS	TS1	0.706	0.619	0.778	0.542
	TS2	0.832			
	TS3	0.660			
T	T1	0.781	0.737	0.835	0.560
	T2	0.762			
	T3	0.704			
	T4	0.744			
BCHAIN	BCHAIN1	0.812	0.766	0.863	0.678
	BCHAIN2	0.841			
	BCHAIN3	0.817			
BMI	BMI1	0.817	0.827	0.880	0.597
	BMI2	0.856			
	BMI3	0.844			
	BMI4	0.783			

4.6. Structural Model

As shown in both Table 3 and Figure 2, the structural model was tested to generate the related values of the path coefficient (β) and the corresponding significant T value in addition to the explained variance of the endogenous variable represented by (R^2). Based on 5000 bootstraps random resamplings, T values were calculated.

Table 3. Hypothesis test results.

	Original Sample	Sample Mean	Standard Deviation	T Statistics	*p* Values
BDAC → BMI	0.731	0.728	0.047	15.676	0.000
BCHAIN → BMI	0.114	0.114	0.055	2.072	0.039
BDAC → CENTRP	0.299	0.296	0.094	3.176	0.002
BCHAIN → CENTRP	0.327	0.331	0.099	3.303	0.001
CENTRP → BMI	0.085	0.088	0.040	2.109	0.035

The results show that both the BDAC and BMI relationships are moderated by environmental uncertainty (β = 0.136, T = 2.501, p = 0.013), as is the relationship between blockchain adoption and BMI (β = 0.209, T = 3.624, p = 0.000).

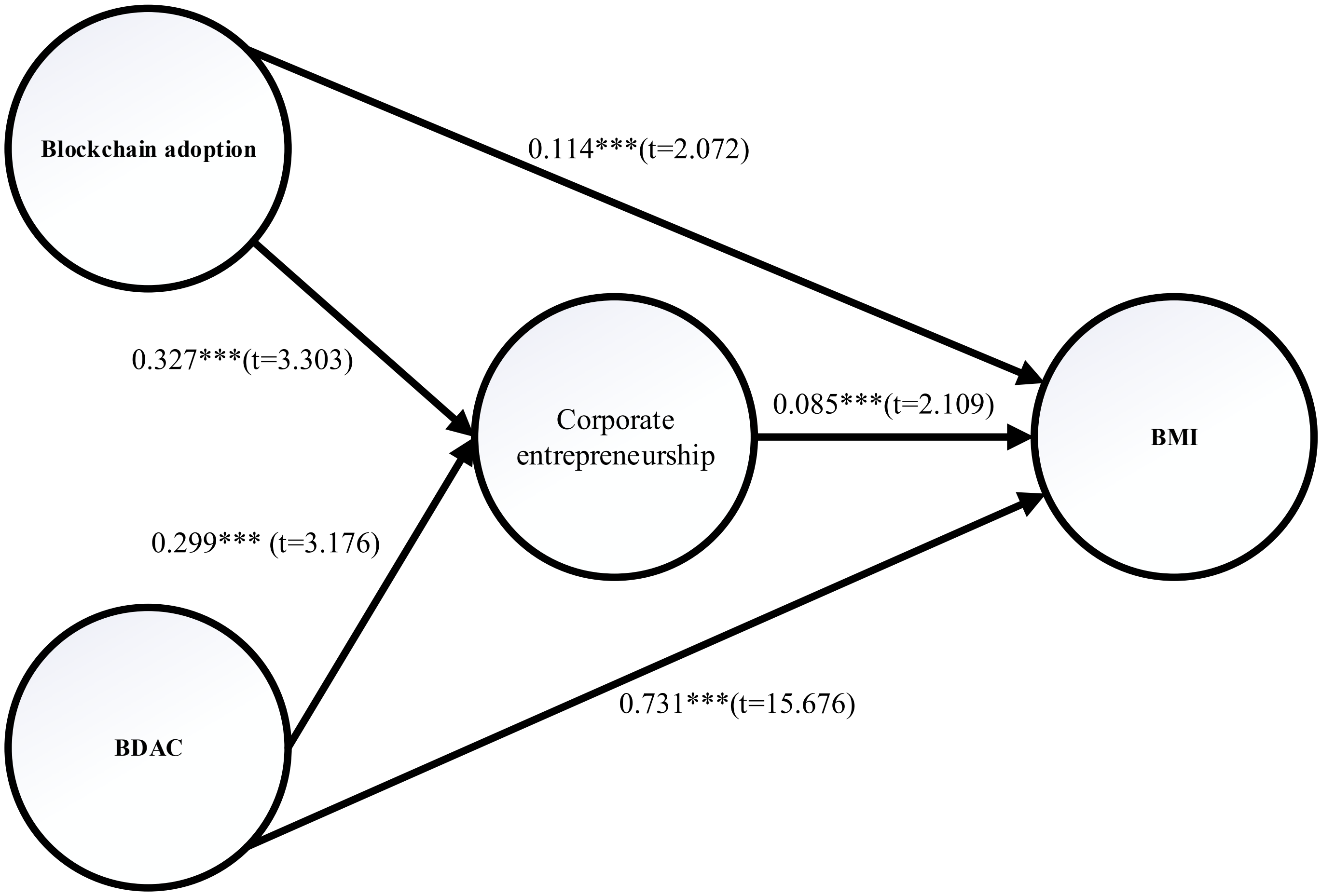

Figure 2. Causal relationship of the structural model. Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Based on the results of the PLS analysis, all hypotheses were confirmed. The significant effect of BDAC on BMI was confirmed by the first hypothesis, where β = 0.731, T = 15.676, and p = 0.000. This indicates that BDAC has a significant impact on BMI. Furthermore, the second hypothesis was also supported by the given values of β = 0.0114, T = 2.072, and p = 0.039, indicating that blockchain adoption significantly impacts BMI. The third hypothesis, representing the direct positive effects of BDAC on corporate entrepreneurship, was also confirmed, where β = 0.299, T = 3.176, and p = 0.002. The fourth hypothesis, based on the direct and positive impact of blockchain adoption, is also supported, where β = 0.327, T = 3.303, and p = 0.001. Finally, Hypothesis 5 confirmed that corporate entrepreneurship has a significant positive effect on BMI (β = 0.085, T = 2.109, and p = 0.035).

In terms of corporate entrepreneurship, the structural model explained 48% of the variance (R^2 = 0.483), and for BMI, it explained 51% of the variance (R^2 = 0.507). Thus, the

R^2 values show that the model is moderate to strongly predictive [127]. The formula for calculating the goodness of fit (GoF) proposed by Wetzels et al. [128] is GoF = $\sqrt{}$ (average AVE) × $\sqrt{}$ (average R-squared): GoF = $\sqrt{}$ (0.498) × $\sqrt{}$ (0.495) = 0.495. According to Wetzels, Odekerken-Schröder and Van Oppen [128], GoF thresholds of 0.1 is small, 0.25 is medium, and 0.36 is large. They assumed a minimum average AVE of 0.5 and used Cohen's rule of thumb when it comes to the effect sizes (small, medium, and large) [129]. Based on these threshold values, the GoF of the model was adequately large, which supported the validity of the model. Our analysis of R^2 was followed by an analysis of the predictive relevance of exogenous variable Q^2 [130]. Our results for Q^2 indicate that BMI (Q^2 = 0.215) and CE (Q^2 = 0.244) are above zero, indicating sufficient predictive relevance [127].

With regard to the mediation effect of corporate entrepreneurship between BDAC and BMI and between blockchain adoption and BMI, the direct and indirect effects, as well as the total effect, are shown in Table 4. Upon calculating the total effect, BDAC was found to have a significant effect on BMI. After calculating the total effect, BDAC was found to have a significant effect on BMI (β = 0.0716, p = 0.000, T = 13.884), and blockchain adoption was found to have a significant effect on BMI (β = 0.181, p = 0.002, T = 3.093). With the inclusion of corporate entrepreneurship as a mediator, the direct effect of BDAC on BMI and blockchain adoption on BMI was found to be significant (β = 0.702, p = 0.000, T = 13.433 and β = 0.151, p = 0.017, T = 2.355, respectively), and the indirect effect was also significant (β = 0.123, p = 0.010, T = 2.405 and β = 0.316, p = 0.000, T = 6.096, respectively). And, blockchain adoption was found to have a significant effect on BMI (p = 0.002, T = 3.093). With the inclusion of corporate entrepreneurship as a mediator, the direct effect of BDAC on BMI and of blockchain adoption on BMI was found to be significant, where β = 0.702, p = 0.000, T = 13.433 and β = 0.151, p = 0.017, T = 2.355. In contrast, the indirect effect was also significant, where β = 0.123, p = 0.010, T = 2.405 and β = 0.316, p = 0.000, T = 6.096, respectively. Therefore, corporate entrepreneurship partially mediates the relationship between BDAC and BMI as well as blockchain adoption on BMI.

Table 4. Mediator test.

	Total Effect			Direct Effect				Indirect Effect		
	Coefficient	*p* Value	T Value	Coefficient	*p* Value	T Value		Coefficient	*p* Value	T Value
BDAC-BMI	0.716	0.000	13.884	0.702	0.000	13.433	BDAC-CE-BMI	0.123	0.010	2.405
BCHAIN--BMI	0.181	0.002	3.093	0.151	0.017	2.355	BCHAIN-CE-BMI	0.316	0.000	6.096

5. Discussion

The current study has drawn attention to the role of big data as a new, innovative, and dynamic capability that can be exploited to enhance a firm's performance [29,50,69,82,123]. The current study is one of the very few to address the impact of BDAC on innovation [69], particularly BMI [3]. Recent literature highlights the potential of blockchain to complement big data analytics [38,131] and, therefore, to increase the probability of creating new BMs that overcome some of the pitfalls of big data analytics [6,132]. However, this study addresses the impact of BDAC and blockchain adoption on BMI.

Furthermore, it investigates how corporate entrepreneurship moderates this relationship and how environmental uncertainty moderates the relationship between BDAC and BMI. Both variables have been identified to significantly contribute to and encourage companies to react and cope with external forces and turbulent environments in a successful way by adopting digitally advanced technologies [32,133]. Hence, this empirical study contributes to an emerging research stream that emphasises the complementary nature of BDAC and BC as a blockchain-based data-centric) technology to be used by companies to strengthen their business models. The empirical results reaffirm that BDAC and blockchain have a significant role in business model innovation. Based on these results, BDAC has a positive effect on BMI because companies that are able to react rapidly to uncertain and changing environments can perform better than firms that are not able to do so. This is consistent with studies that have examined the impact of BDAC on companies' performance and business models and the role of information in value creation [3,50]. Accordingly, BDAC can provide companies with the necessary information to improve their operations, understand customers, and create new products, as well as assist companies in identifying new business opportunities and fine-tuning their marketing campaigns [123,134]. This information can be used to renovate the existing business model or to create a new one [15].

The results also indicate that the use of BC is statistically significant for BMI, which is similar to previous research that shows how blockchain can generate new value and solve economic problems [16–18,135]. For example, Sun, Jiang, Jia and Wang [135] argue that business value in cryptocurrency models, automated processes, and analytical processes is derived from interactions with organisations, people, and technologies. Moreover, blockchain-based applications can also solve various economic problems, such as the storage of information, the sharing of consensus, and the formation of governance systems. In addition, Nowiński and Kozma [18] found that blockchain can disrupt business models and change their building blocks.

Moreover, corporate entrepreneurship, as an intermediary, moderates the relationship between BDAC and BC adoption. This means that the creativity and innovative behaviour of corporate entrepreneurs [32,136], which guides a company to produce new products and services, play central roles in BDAC and BC adoption, which, in turn, help them innovate through business modelling. This is consistent with previous studies that emphasise the importance of corporate entrepreneurship in BMI [21] and its mediating role in improving performance [32,103].

Finally, the results suggest that environmental uncertainty moderates the relationship among BDAC, BC adoption, and BMI, such that more environmentally oriented firms that have a stronger record of innovativeness are more likely to adopt BC and use BDAC to innovate their business model. This is in line with prior research that increasing uncertainty in the external environmental context strengthens the relationship between BDAC and BMI [137]. This applies to BC and business performance [42].

Apart from the above, our findings have significant implications for sustainable development, aligning with the United Nations' Sustainable Development Goals. The synergistic effects of BDAC and blockchain on BMI contribute to economic, social, and environmental sustainability. Economically, the positive impact of BDAC and blockchain on BMI suggests more efficient resource allocation and sustainable business models [3,46,138]. Socially, blockchain's influence on BMI indicates its potential to enhance transparency and trust in business operations [139], while BDAC's strong effect suggests deeper insights into stakeholder needs [137]. Environmentally, BDAC's impact on BMI points to data-driven decision-making that can lead to more environmentally conscious practices [140]. The mediating role of corporate entrepreneurship underscores the importance of innovative thinking in developing sustainable business models across all three dimensions [141]. However, realising these benefits requires intentional focus on sustainability goals, and future research should explicitly examine how BMI resulting from BDAC and blockchain adoption translates into measurable sustainability outcomes, while also considering the potential environmental costs associated with these technologies [142].

In summary, our results add to the literature on dynamic capabilities and suggest that firms' unique dynamic capabilities, enabled by the deliberate orchestration of internal and external big data resources, can promote strategic adjustments and novel business model innovations and generate sustainable competitive advantages, especially in an uncertain business environment [143]. Companies have the chance to develop BDAC by investing in the fundamental resources that support these capabilities, such as tangible resources, human skills, and intangible resources [138]. These unique resources enable the extraction of important knowledge from raw data, allowing organisations to be informed about present and potential changes in the competitive environment [137]. This information can be efficiently utilised not only for reengineering corporate processes, creating new goods, and serving customers but also for generating new ways of engaging stakeholders and communities. Conclusively, it can be deployed for the development of new sustainable business models.

5.1. Theoretical Implications

Theoretically, this study adds to the body of knowledge in several ways. Therefore, we examined the effect of BDAC on BMI. First, this study extends existing research on the importance of BDAC, demonstrating quantitatively how BDAC can affect BMI through an empirical study. There is some anecdotal evidence that BDACs support companies' innovation, but there is little theoretical groundwork to support this claim. The current study provides some theoretical underpinnings of how BDACs, as a new and innovative technology, can help achieve BMI.

As a second contribution, we examine the role of BC adoption in developing BMI, a field that has been under explored. To the best of our knowledge, no empirical studies have examined this relationship using empirical evidence despite the existing literature showing the technical and conceptual impacts of BC. According to our results, companies can adopt blockchain as an enabler for new or incremental business models. This is because of its ability to create trust and transparency among all parties involved in a transaction and its decentralised nature.

The third contribution of this study is that it shows how corporate entrepreneurship mediates the relationship between BDAC and BMI in the entrepreneurship literature. It has been suggested that corporate entrepreneurship plays an influential role in determining BMI, but scant empirical evidence supports this. This study provides empirical evidence on how corporate entrepreneurship mediates the relationship between BDAC and BMI. As both blockchain adoption and BDAC use this highlight, companies need to leverage ICT resources innovatively to remain competitive and perform well, and it is crucial to seize and nurture the opportunities they provide in an environment that fosters entrepreneurship.

Fourth, we complement and extend the literature by providing evidence that environmental uncertainty moderates the relationship between BDAC and BMI. Given that both internal and external factors affect a company's innovation process, it is crucial to understand their interactions. In sectors characterised by rapid change and intense competition, blockchain implementation and BDAC usage are essential for BMI's success of BMI. This was the first study to document such results that supported the idea that businesses should invest more in BDAC and blockchain by choosing data-driven decision-making when they are under pressure to compete and have a pressing need to gain an advantage over competitors. In addition to offering insights into existing products and services, BDAC and blockchain may also provide insights into drastically new products and services that could help drive significant improvements. It is becoming more difficult to base decisions on information or time as the market becomes more rapidly paced.

5.2. Managerial Implications

The practical implications of this study suggest that companies should consider both BDAC and blockchain adoption when seeking to achieve BMI, as these technologies, if combined, can reap more benefits and lead to more options for innovating their business models. In addition, companies functioning in more uncertain environments may be less willing to adopt new technologies and innovations, regardless of whether they adopt BDAC or blockchain. Practitioners should consider these implications when assessing the potential roles of BDA and blockchain in organisations' innovation strategies. In addition, practitioners should consider ways to mitigate the effects of environmental uncertainty by investing in advanced technologies to renovate their business models.

While our study demonstrates the potential benefits of integrating blockchain and big data analytics for business model innovation, it is important to acknowledge the practical challenges and barriers companies face when adopting these technologies. Based on our findings, key challenges may include the following: (1) technical complexity, as evidenced by the need for specialised skills in both BDAC and blockchain; (2) data quality and integration issues, particularly for big data analytics, which our results show is crucial for BMI; and (3) potential organisational resistance to the required changes, as suggested by the mediating role of corporate entrepreneurship in our model. To address these challenges, companies may consider investing in employee training to develop BDAC and blockchain skills, fostering a culture of corporate entrepreneurship to drive innovation, and adopting a phased approach to implementation that aligns with the company's level of environmental uncertainty. As our results indicate that environmental uncertainty moderates the relationship between these technologies and BMI, companies should also remain flexible and adaptive in their implementation strategies. These approaches can help companies navigate the complexities of adopting blockchain and big data analytics, ultimately enabling them to leverage these technologies for business model innovation, as demonstrated in our study.

This finding has important managerial implications—companies should sharpen their corporate entrepreneurship to benefit from their BDACs and from blockchain. Moreover, corporate entrepreneurship needs to be strengthened to promote creativity and innovation and stay competitive. As the growth of BDACs and their opportunities will skyrocket in the future, corporate entrepreneurship should be encouraged to take advantage of this ramped-up growth. Although environmental uncertainty could moderate the relationship between blockchain and the use of BDACs, corporate entrepreneurship should still be considered in terms of the potential mechanisms for companies to counter environmental uncertainty.

The low-bounded reliance of corporate entrepreneurship on individuals in companies, however, can be mitigated through some managerial measures that strengthen people's own willingness to perform well. For instance, companies could use the 'reward' mechanism, such as providing the employees with financial or non-financial incentives for innovative trials and exploration activities making use of big data and blockchain, to encourage internal collaboration in innovative co-ops characterised by high risk and responsibility.

In addition, our findings provide valuable insights for managers who want to improve their organisation's sustainability efforts through BDAC and blockchain. We recommend integrating sustainability goals into BDAC strategies to optimise resource usage, reduce waste, and track progress on sustainability targets. Blockchain can enhance supply chain transparency and traceability, enabling better monitoring of sustainability practices. Managers should promote a culture of corporate entrepreneurship to encourage sustainable innovation, empowering employees to use insights from these technologies to develop new, sustainable business models. Given the impact of environmental uncertainty, businesses should utilise BDAC and blockchain to enhance adaptability to evolving sustainability requirements. However, managers must be mindful of potential negative impacts, such as blockchain's energy consumption, and work to mitigate these through careful selection and implementation strategies. By leveraging BDAC and blockchain strategically, businesses can drive innovation and advance their sustainability agenda.

Overall, this study provides valuable insights into the relationship between BDAC and blockchain adoption in BMI. Practitioners can use this information to better assess their organisation's ability to innovate and plan for future innovation challenges. Additionally, corporate entrepreneurship can help companies stimulate creativity and improve organisational communication. While there are many opportunities for BDAC and blockchain adoption in today's market, companies should continue to focus on developing their corporate entrepreneurship to capitalise on these new technologies.

5.3. Limitations and Future Research

This study has substantial importance and value, but there are a number of shortcomings that offer intriguing opportunities for further research. Convenience sampling was used to select respondents. Although the data gathered from the Australian market were considered appropriate, they have some limitations in terms of generalisability. Additionally, the self-report questionnaires used to obtain the data posed a significant constraint on the construct validity [144].

In addition, this study was based on a cross-sectional survey of a sample of Australian companies. To increase the generalisability of the results, future research should collect longitudinal data from a broader range of businesses across multiple geographical regions. These studies can also infer how BDAC influences BMI through stronger causal inferences.

While the current study examines the impact of BDAC usage and blockchain adoption on BMI without distinguishing incremental from radical innovation, BMI consists of both incremental and radical innovations [15], and the impact of adopting these technologies can vary. As a result, future studies could use this fact as a basis for building their assumptions.

Finally, the study considers corporate entrepreneurship as a mediator between the independent variables (BDAC and blockchain) and the dependent variables (BMI); however, the literature advocates that corporate entrepreneurship consists of a variety of dimensions rather than a composite one [145,146]. Future research should consider this limitation and expand its models to examine the most important aspects of corporate entrepreneurship.

6. Conclusions

This study contributes to the existing body of knowledge on the utilisation of BDAC andBC adoption as transformative technologies in driving BMI activities, with significant implications for sustainable business practices. Firstly, it demonstrates the positive impact of BDAC and BC adoption as dynamic capabilities on BMI, potentially leading to the development of more sustainable business models. Secondly, it provides empirical evidence that corporate entrepreneurship plays a mediating role in the relationship between BDAC and BMI, as well as between BC adoption and BMI. This suggests the possibility of cultivating a strategic orientation characterised by entrepreneurial decisionmaking, enabling individuals to create new value, products, and services that not only benefit customers but also contribute to sustainability objectives.

Furthermore, this study presents compelling evidence that adopting and utilising these technologies are more prevalent in high-uncertainty environments, indicating their potential to enhance organisational resilience and adaptability in the face of sustainability challenges. In summary, firms are more inclined to embrace and employ innovative technologies that can alleviate uncertainty, foster BMI, and promote sustainable practices in complex and uncertain contexts. In conclusion, this study not only highlights the synergistic and complementary nature of BDAC and BC adoption in relation to BMI but also provides insights for companies to explore new avenues for future growth that align with the Sustainable Development Goals. By harnessing these technologies, businesses can innovate their models to be more economically viable, socially responsible, and environmentally conscious, thereby contributing to a more sustainable future.

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