Positioning Space Tourism within Astrotourism: Pathways for Commercialization and Market Development

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Abstract: Astrotourism is increasingly recognized as a niche form of tourism that integrates science, culture, and experience through human engagement with the universe. Within this broader category, space tourism represents one of its most prominent strands, shaped by technological progress and the growing demand for knowledge-driven encounters. While interest in both astrotourism and space tourism has expanded, the commercialization of these activities remains underexplored, particularly regarding how markets, business models, and visitor experiences evolve in tandem. To address this gap, this study examines how Business Model Innovation (BMI) has been conceptualized and applied within the context of terrestrial astrotourism, and what implications it holds for the sustainable commercialization of space tourism. A systematic literature review (SLR) was conducted following the PRISMA approach, focusing on 12 scholarly publications indexed in Scopus. Each article was analyzed through thematic synthesis to identify its central focus, treatment of business model components, and orientation toward commercialization. The analysis was guided by a framework distinguishing five forms of business model innovation: value proposition, marketing, process, revenue model and organizational innovation. The findings reveal that commercialization in astrotourism is primarily driven by innovations in value proposition, market expansion, and organizational collaboration. These developments indicate a transition from conventional sightseeing toward immersive, educational, and community-embedded experiences that generate emotional, cultural, and environmental value for visitors. While process and revenue innovations appear less developed and often implicit, emerging practices such as emotional experience staging, technology-assisted interpretation, and coordinated dark-sky management reflect increasing maturity in how astrotourism products are designed and delivered. More broadly, astrotourism functions as a testing ground for new forms of destination governance and experience-based value creation that may inform future models of responsible space-related tourism. Its emphasis on sustainability, inclusiveness, and local participation offers insights for constructing resilient and ethically grounded tourism frameworks. Further research should examine digital mediation, financial sustainability, and impact assessment to clarify how astrotourism can contribute to sustainable pathways within the evolving space economy.

Keywords: Astrotourism, Business Model Innovation, Commercialization, Space Tourism.

1. Introduction

Astrotourism has gained significant traction in recent years as travelers increasingly seek meaningful connections to nature and educational experiences. This niche form of tourism, centered on astronomy-related leisure with the intention of observing the celestial sphere and/or its astronomical heritage, has grown in parallel with rising concerns about light pollution and global movements toward sustainable travel (Araya-Pizarro and Verelst, 2023; Tapada et al., 2021). Its appeal lies not only in its scientific and cultural dimensions but also in its potential to support rural economies and foster environmental awareness.

Despite its growing popularity, astronomy-related tourism still faces challenges in establishing viable and scalable business models. Key constraints include limited or seasonal demand, inadequate infrastructure in rural dark-sky areas, and the difficulty of balancing commercialization with conservation goals (Tapada et al., 2021). These tensions underscore the need to rethink and explore how organizations segment markets, create value propositions, design, and implement them to achieve the long-term sustainability of astrotourism ventures (Teece, 2010).

While recent studies have attempted to consolidate the emerging body of knowledge on astrotourism—for instance, through systematic reviews (PRISMA) (Tapada et al., 2021) and bibliometric analyses (Araya-Pizarro and Verelst, 2023), none have specifically examined how business model innovation supports the design, growth, or sustainability of astronomy-based tourism initiatives. This gap is increasingly relevant as global discourse begins to link terrestrial astrotourism with commercial space tourism: one serving as an accessible entry point for public engagement with the cosmos, and the other representing its speculative frontier. It has been suggested that the progression toward space tourism is unlikely to occur instantaneously, but must instead develop from grounded terrestrial experiences such as astrotourism (Cater, 2010) Understanding how business models evolve within this domain may therefore offer conceptual insights for future space-economy

development, where value creation is similarly rooted in experience, education, and technological emergence.

To address this gap, this study conducts a Systematic Literature Review (SLR) focusing on the types of business model innovations currently applied in astrotonomy tourism. The findings are expected to contribute to scholarly discourse and provide a conceptual foundation for translating terrestrial innovation into the emerging space tourism market.

2. Literature Review

2.1 Astrotourism

Astrotourism, or astronomy-based tourism, can be defined as a sustainable tourism segment that invites public participation in observing the night sky and celestial objects, positioning the untouched night sky itself as an essential and marketable attraction (Collison and Poe, 2013). Astrotourism relies on the ecological integrity of pristine night sky, which are highly sensitive to light pollution and other environmental disruptions (Kanianska et al., 2020). As such, the development of astrotourism is inherently tied to conservation efforts, particularly through dark-sky protection initiatives. Further refining the scope of astrotourism, a typology was proposed to classify the phenomenon into three main categories (Matos, 2017) :

- ***Space Tourism***, referring to orbital or suborbital travel experiences and beyond Earth's orbit.
- ***Atmospheric Space Tourism,*** which includes experiences such as zero-gravity flights and high-altitude ballooning within Earth's upper atmosphere.
- ***Terrestrial Astrotourism,*** which focuses on earthbound activities like stargazing, aurora watching, observatory visits, dark-sky-based experiences, space movies and virtual space travel.

Space tourism continues to captivate the public imagination through its association with advanced technology and exclusive participation, while terrestrial astrotourism represents an early, more accessible modality of space engagement. Therefore, viewing astrotourism holistically provides a more comprehensive basis for theorizing commercialization pathways, rather than limiting analysis to space-oriented models.

2.2 Business Model Innovation

Business model innovation begins with a company's ability to create a value proposition reflected in customer value added, which occurs when perceived value exceeds price, resulting in a surplus of benefits for customers (Matzler et al., 2013). Value propositions, positioned at the front end of the business model, determine the direction of change in the distribution system and revenue logic (Günzel and Holm, 2013). Value propositions encompass all solutions to customers' primary needs, including product and service usability, accessibility, affordability, and relevance to the social context (Gebauer et al., 2017). In short, value proposition in BMI is a configuration of primary benefits in functional, emotional, social, and contextual value that creates a higher willingness to pay.

Market innovation is a change in how companies exploit market opportunities (Teece, 2010) through reconfiguring the architecture of value creation, delivery, and capture, including changes in who is served and how value is delivered to the market (Foss and Saebi, 2018). It changes the relationships between actors, activities, and transactions that reshape how value exchange occurs in the network of business model activities (Foss and Saebi, 2018; Haftor and Climent Costa, 2023; Teece, 2010). In short, market innovation is needed for the adjustment of business models to suit the ever-evolving market dynamics.

Process innovation refers to changes in the logic of value creation, namely how organizational activities and processes are structured to generate and deliver value more efficiently and effectively (Matzler et al., 2013). The designed changes concern the architecture of complementary activities, rather than minor operational improvements (Foss and Saebi, 2018). These include how the organization structures its operations, costs, activity systems, and value delivery mechanisms to convert value into profit (Teece, 2010). Although some of these processes overlap with value propositions and organizational innovation, analytically they are positioned as process innovations because they directly change the company's value creation mechanisms.

Revenue model innovation refers to a company's ability to generate actual revenue through innovative monetization mechanisms, such as changes in pricing structures, revenue sources, or payment logic (Matzler et al., 2013). Revenue model innovation needs to be designed to align with customer accessibility and affordability, particularly in the context of an inclusive market, thus enabling a balance between social value creation and

financial sustainability of the business (Gebauer et al., 2017).

Organizational innovation refers to an organization's ability to adapt through learning, changes in structure, processes, procedures, norms, and innovation decision-making mechanisms (Buliga et al., 2016). This ability includes updating value creation systems, value propositions, and value capture mechanisms (Moradi et al., 2021).

3. Materials and Methods

This study adopts a Systematic Literature Review (SLR) approach to identify how Business Model Innovation (BMI) is discussed, framed, and manifested within astronomy-related tourism. The use of SLR is considered appropriate because previous research in other industries has also employed SLR as a method to map business models and detect forms of BMI, utilized literature-based synthesis to structure BMI knowledge and classify innovation patterns (Downs and Velamuri, 2016; Tell et al., 2016). The review process was structured following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which consisted of four key stages: identification, screening, eligibility assessment, and final inclusion (Moher et al., 2009).

3.1 Data Collection

The literature search was performed in April 2025 using the Scopus database, chosen for its wide coverage and reliability in indexing high-quality, peer-reviewed academic publications. The following search string was applied to identify relevant studies:

("astrotourism" OR ("astronomical" AND "tourism") OR ("dark" AND "sky" AND "tourism") OR ("stargazing" AND "tourism") OR ("astro" AND "tourism")) AND ("revenue" OR "entrepreneurship" OR "tourism development" OR "management")

The search was limited to articles published in English in peer-reviewed journals, following the four key stages outlined in **Figure 1**.

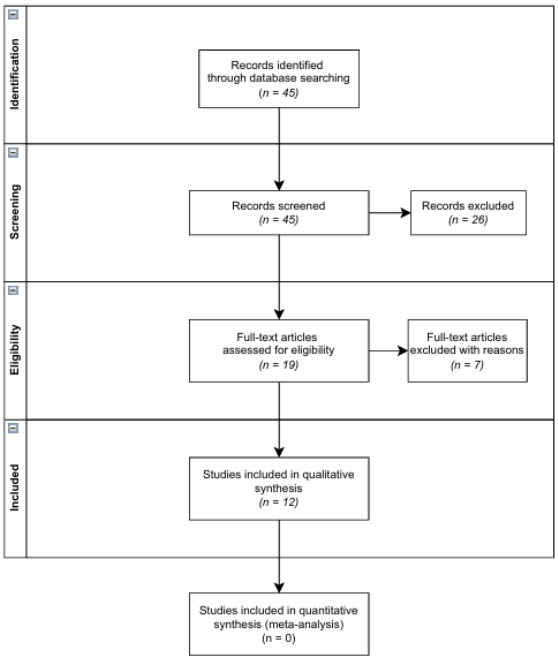

Figure 1: The Four Key Stages of the Literature Review in Astrotourism Research

3.2 Selection Process

A total of 45 records were initially retrieved, spanning publication years from 2002 to 2024. The selection process began with a title and abstract screening to assess the relevance of each paper to the core themes of astronomy tourism and business model innovation. Although the initial search was restricted to English-language publications, the manual screening of titles and abstracts identified a few misclassified non-English articles, which were subsequently excluded during the eligibility assessment. Studies were excluded if they met

at least one of the following criteria:

- Focused exclusively on general tourism without specific reference to astro-related tourism.
- Addressed highly technical or location-specific data (e.g., meteorological reports, light pollution measurements) without implications for business or tourism.
- Did not engage with themes of entrepreneurship, revenue generation, business model or tourism management.

Following this screening, 19 articles met the eligibility criteria. Each full text was read thoroughly. During this phase, seven additional articles were excluded. These articles initially appeared relevant, but a closer examination revealed that they did not engage analytically with the business model transformation or innovation dimensions. These studies still contributed valuable contextual insights, such as visitor perceptions, sustainability perspectives, regional development impacts, and the conceptual positioning of astrotourism. However, they did not examine value-creation logic, market structuring, organizational arrangements, revenue mechanisms, or operational innovation in a way consistent with the BMI framework.

3.3 Analysis Strategies

The selected articles were analyzed using secondary thematic analysis to explore how commercialization and market development are framed within the context of astronomy-related tourism. Each publication was examined to identify its central focus, as well as its treatment of business model components and innovation strategies. The classification of innovation types followed an established framework distinguishing five forms of BMI: value proposition, market, revenue model, process, and organizational innovation. The primary focus, data collection, and data analysis methods were identified across the selected studies.

As business model innovation is inherently multidimensional, articles were allowed to be classified across multiple BMI categories when conceptually justified. Classification was guided by a theory-driven framework and based on the substantive emphasis of each study's core arguments and findings rather than incidental references. To strengthen analytical rigor, the categorization process involved iterative reading and systematic cross-comparison across studies to ensure internal coherence within the five BMI dimensions. A detailed summary of the reviewed studies is provided in **Table 1.**

Table 1: Summary of Reviewed Astrotourism Articles

Authors	Primary Focus	Data Collection	Data Analysis Method	Type of Innovation				
				V	M	P	R	O
Blundell et al. (2020)	Investigates how DST can contribute to sustainable regional destination development with a triple bottom line approach plus ethics and education	Semi-structured interviews with tourism stakeholders	Thematic analysis	●	●			
Cater C.I. (2010)	Proposes a staged framework for the evolution of astrotourism from terrestrial experiences to commercial space tourism.	Conceptual/ Theoretical (literature-based)	Critical literature synthesis.	●				●
Collison and Poe (2013)	Explores the implementation of dark sky programs in national parks as an educational and experiential offering	Descriptive case-based documentation	Narrative descriptive analysis.	●	●	●		
Dalgleish et al. (2019)	Uses astronomy for capacity building, guide training, and rural development through DST	Program-based qualitative study	Applied case study reflection.			●		●
Fernández Hernández et al. (2022)	Analyzes tourist preferences and willingness to pay for different stargazing infrastructures	Discrete Choice Experiment (DCE)	Econometric modeling	●	●	●	●	
Ibrahim et al. (2012)	Presents a one-stop astronomy center blending Islamic values, education, and tourism.	Descriptive case analysis of architectural and programmatic design.	Narrative-descriptive interpretation.	●	●	●	●	●
Rodrigues et al. (2015)	Case study of Dark Sky Alqueva, highlighting local integration and	Interviews, observations, site-	Qualitative case analysis.	●	●		●	●

Authors	Primary Focus	Data Collection	Data Analysis Method	Type of Innovation				
				V	M	P	R	O
	tourism product diversification.	based reports.						
Rodrigues et al. (2022)	Investigates how the feeling of "awe" influences satisfaction and return intentions.	304 survey responses	PLS-SEM	●		●		
Rodrigues et al. (2023)	Examines how novelty, hedonism, and meaningfulness influence tourist loyalty in astrotourism experiences.	296 surveys at a Portuguese astrotourism event.	PLS-SEM	●		●		
Tapada et al. (2021)	Analyzes stakeholder perceptions of network-based planning in the development of an astrotourism project in Portugal.	Semi-structured interviews with stakeholders.	Social Network Analysis (SNA) and thematic analysis.	●	●	●	●	●
Weaver D. (2011)	Positions astrotourism within ecotourism, emphasizing conservation and education in nature-based night-sky experiences.	Conceptual/Theoretical (literature-based).	Analytical discussion and conceptual positioning.	●	●	●		●
Xanthakis et al. (2024)	Analyzes the digital visibility and promotional strategies of International Dark Sky Parks.	Content analysis of 60+ websites.	Descriptive and content-based comparison.	●		●	●	●

* V: value proposition innovation, M: market innovation, P: process innovation, R: revenue model innovation, O: organizational innovation

4. Findings and Discussions

4.1 Value Proposition Innovation

The systematic reviews show that astrotourism offers a diverse spectrum of value propositions, beginning with the value of immersive and multisensory experiences, as demonstrated by night-sky interpretation programs that deliver "*sensory-rich experiences*" in Bryce Canyon (Collison and Poe, 2013) and the characterization of astrotourism as a niche that supports sensory and cognitive engagement (Tapada et al., 2021). Emotional value becomes significant in astronomical tourism experiences, which are intentionally designed to evoke awe, thereby enhancinge satisfaction and behavioral intention (Rodrigues et al., 2022). Likewise, novelty, meaningfulness, knowledge, and involvement operate as experiential stimuli that trigger cognitive and emotional responses, such as hedonism and refreshment, ultimately shaping memorable experiences and loyalty (Rodrigues et al., 2023). A value of well-being and emotional restoration is also reflected in the spiritual and restorative qualities associated with night-sky experiences (Blundell et al., 2020), as well as reflections on the loss of opportunities for contemplation due to light pollution (Tapada et al., 2021).

Community authenticity value arises from local community involvement and the reinforcement of rural cultural identity (Rodrigues et al., 2015) as well as from the positive sociocultural outcomes of celestial ecotourism (Weaver, 2011). A dark-sky conservation value is likewise evident, especially in the emphasis on preserving *unpolluted* night-sky conditions for sustaining tourism experiences (Weaver, 2011) and in conservation-oriented destination development (Rodrigues et al., 2015). Cultural and heritage value also emerges through UNESCO's recognition of the starry sky as *"cultural and universal heritage*" and its relevance to astronomical heritage (Rodrigues et al., 2015), consistent with the role of *archaeoastronomical heritage* highlighted in astrotourism activities. In addition, astrotourism promotes educational astronomy values through observatories and public programs that provide opportunities for learning and the dissemination of astronomy knowledge (Tapada et al., 2021).

On other hand, activities such as astrophotography add further value by enabling visual interpretation of dark skies (Tapada et al., 2021), while a technology-enhanced value arises from the use of modern astronomical infrastructures that deepen observational experience (Fernández-Hernández et al., 2022).

4.2 Market Innovation

Market innovation in astrotourism primarily manifests through the expansion of audience segments beyond astronomy enthusiasts. Activities involving public education, guided night-sky observation, and sensory engagement attract non-astronomy visitors seeking unique natural experiences (Tapada et al., 2021). Evidence suggests that celestial ecotourism can "*complement or even substitute*" for traditional ecotourism attractions (Weaver, 2011), while also attracting wellbeing-oriented visitors pursuing psychological restoration (Blundell et al., 2020), and engaging general park visitors and families through structured night-sky programming (Collison and Poe, 2013).

Astrotourism also involves strategic repositioning and category formation. The creation of a distinct dark-sky market category, conceptualized as celestial ecotourism, constitutes a unique form of ecotourism focused on pristine night conditions (Weaver, 2011) and is further strengthened by broader interest in astronomy-related tourism phenomena (Cater, 2010), illustrating deliberate market differentiation.. Destinations are also repositioned through dark-sky branding, such as Alqueva's transformation into a night-sky destination (Rodrigues et al., 2015) and Bryce Canyon's shift from a geology-centric identity toward a night-sky–oriented profile (Collison and Poe, 2013).

Market innovation is further strengthened through cultural and community embedding. The designation of the starry sky as *cultural and universal heritage* and its integration with rural cultural landscapes in the Dark Sky Reserve of Alqueva (Rodrigues et al., 2015). Moreover, astrotourism exhibits community-linked market integration, in which local involvement and rural cultural identity are integral to the destination's appeal (Rodrigues et al., 2015), aligning with the positive sociocultural impacts observed in celestial ecotourism (Weaver, 2011).

The technology-enabled expansion of market reach is evident, with astronomical infrastructures and interpretation technologies in sites such as Teide National Park attracting non-experts (Fernández-Hernández et al., 2022). Meanwhile, digital planetariums, robotic observatories, and internet-controlled telescopes at the Al-Khawarizmi Complex expand access to general visitors, families, and students (Ibrahim et al., 2012).

4.3 Process Innovation

Astrotourism is expressed through diverse operational and experiential mechanisms. Destinations incorporate experience design processes that structure meaningful sensory engagement, as seen in Tapada's (2021) emphasis on sensory–cognitive experiences and in Bryce Canyon's *"sensory-rich"* night-sky interpretation programmes (Collison and Poe, 2013). Emotional experience design further reinforces this structuring, as activities are intentionally crafted to evoke awe and related affective states that shape memorable stargazing encounters (Rodrigues et al., 2022). Experiential stimuli such as novelty, meaningfulness, knowledge, and involvement operate as structured elements within this process, strengthening satisfaction and memorability (Rodrigues et al., 2023).

Beyond experiential design, process innovation is supported by institutional and sustainability-oriented mechanisms. Dark-sky preservation processes are embedded within destination management strategies that maintain high-quality night conditions (Rodrigues et al., 2015). It aligns with calls to protect *unpolluted* skies within celestial ecotourism (Weaver, 2011). Capacity building is further strengthened through training processes, such as Namibia's structured guide-training curriculum, which covers astrophysics, star lore, practical astronomy, and light pollution (Dalgleish et al., 2019), complemented by observatory-based dissemination activities (Tapada et al., 2021). Visitor-flow coordination within dark-sky reserves further demonstrates how operational control sustains environmental integrity and experiential consistency (Rodrigues et al., 2015).

Technology functions as an enabling layer that enhances both interpretation and delivery, with astronomical infrastructures and public telescopes enabling accessible scientific engagement (Fernández-Hernández et al., 2022). In addition, educational and interpretive processes are enhanced by digital planetariums, robotic observatories, and internet-controlled telescopes which facilitate public learning and understanding of celestial phenomena (Ibrahim et al., 2012).

4.4 Revenue Model Innovation

None of the reviewed studies explicitly articulate revenue models in structural or financial terms. Revenue mechanisms are therefore absent as a formal analytical dimension within literature. Instead, revenue

innovation appears only implicitly, embedded within descriptions of value creation and destination practices. For example, the framing of astrotourism as a "*unique, rare and valuable*" experience (Tapada et al., 2021) and the emotional depth of night-sky encounters (Xanthakis et al., 2024) indicate potential for premium experience-based pricing. Certification initiatives such as Alqueva's Dark Sky Reserve status (Rodrigues et al., 2015) imply heritage-based commercial positioning. Educational infrastructures including digital planetariums and robotic observatories (Ibrahim et al., 2012), suggest education-oriented revenue streams. Community involvement in service provision also enables local-based revenue participation (Rodrigues et al., 2015), while the use of specialised observation technologies expands possibilities for tech-based add-on services (Fernández-Hernández et al., 2022).

Overall, these patterns suggest that revenue generation in astrotourism remains embedded within value propositions rather than conceptualized as a distinct business model dimension.

4.5 Organizational Innovation

Organizational innovation in astrotourism is manifested through the establishment of governance and sustainability-oriented structures that coordinate the protection and interpretation of the night sky. The Alqueva Dark Sky Reserve exemplifies multi-stakeholder governance, involving local government, community actors, tourism operators, and astronomical institutions in an integrated management framework (Rodrigues et al., 2015) in line with Weaver's (2011) view that celestial ecotourism requires cross-sector ecological coordination. Formal lighting regulation, monitoring systems, and destination-level dark-sky management frameworks institutionalize environmental protection (Rodrigues et al., 2015) while ecological-emotional management logics further embed sustainability within organizational arrangements (Xanthakis et al., 2024). These developments illustrate how astrotourism organizations are evolving toward ecosystem-based, knowledge-intensive configurations.

Beyond governance structuring, organizational innovation also manifests through the institutionalization of knowledge and the hybridization of scientific and community roles. Structured guide-training programmes covering astrophysics, star knowledge, and light pollution (Dalgleish et al., 2019), alongside observatory-based educational functions (Tapada et al., 2021). professionalize service delivery and consolidate expertise as organizational capital. The integration of digital planetariums, robotic observatories, and internet-controlled telescopes bridges professional astronomy and public engagement (Ibrahim et al., 2012), consistent with the broader trend toward knowledge-oriented tourism discussed by Cater (2010). The role of communities is also embedded in organizational structures, as local participation in service provision and cultural interpretation forms a defining component of tourism operations (Rodrigues et al., 2015) and aligns with the sociocultural benefits noted in sky ecotourism (Weaver, 2011). These developments illustrate how astrotourism organizations evolve toward ecosystem-based and knowledge-intensive configurations.

To visualize how these five forms of business model innovation interrelate within the context of astrotourism, a conceptual mapping was developed (see Figure 2). While analytically distinguished for clarity, the five BMI dimensions operate as an interconnected configuration in practice. Adjustments in one dimension may reshape others. For example, shifts in value positioning can reframe market orientation, revenue logic, operational routines, or organizational arrangements. These relationships are context-dependent and adaptive rather than sequential. Accordingly, the framework captures a dynamic configuration of innovation elements instead of a fixed or prescriptive progression.

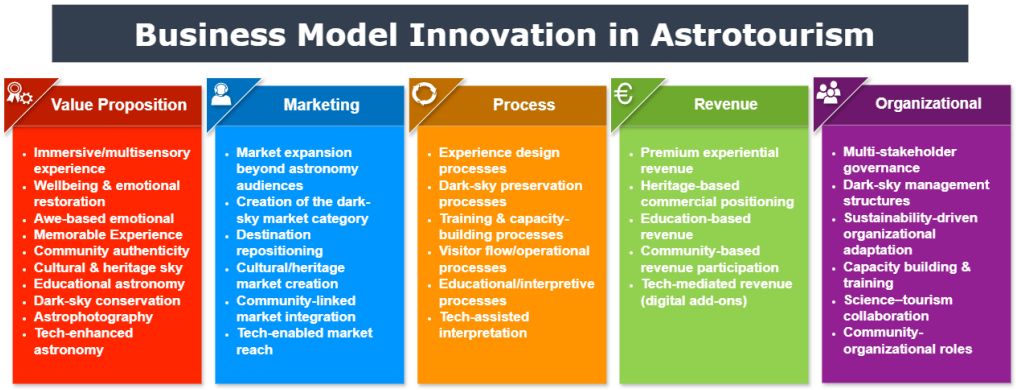

Figure 2: Conceptual Mapping of Business Model Innovation in Astrotourism

5. Conclusion and Future Research

This study examined how BMI has been conceptualized and applied within the emerging field of astrotourism. The review revealed that commercialization in astrotourism is primarily driven by innovations in value proposition innovation, marketing innovation, and organizational innovation. These developments indicate a gradual shift from traditional sightseeing toward immersive, educational, and community-based experiences that create deeper emotional and social value for visitors. While financial and process-related innovations remain underdeveloped, the increasing integration of storytelling and digital tools suggests a growing maturity in how astrotourism enterprises design and deliver their offerings.

From a commercialization perspective, these trends imply that astrotourism functions as an experimental platform where new market structures, revenue models, and governance mechanisms can be tested on a small scale before being adapted to the broader domain of space tourism. The emphasis on sustainability, inclusiveness, and multi-stakeholder collaboration found in astrotourism offers valuable insights for building responsible and resilient space tourism models. Future research should therefore explore how the principles of value co-creation and local participation evident in terrestrial astrotourism can inform the ethical and economic frameworks of space tourism commercialization.

Beyond mapping existing practices, this study advances BMI theory in tourism in three ways. First, it extends BMI analysis to an emerging niche tourism domain where commercialization is intertwined with conservation and educational logic. Second, it demonstrates that in early-stage tourism markets, value and market innovations tend to precede and structurally dominate revenue and process innovations, suggesting a developmental asymmetry within BMI configurations. Third, the findings reveal that revenue mechanisms in astrotourism are embedded within experiential and governance practices rather than articulated as standalone financial structures, thereby challenging the assumption that BMI dimensions evolve uniformly across contexts.

Future research should examine structured analyses of revenue architecture and pricing strategies, develop more digital integration (e.g., VR/AR and platform-based systems) and assess the socio-economic and environmental impacts of astrotourism business models to strengthen empirical grounding.

Ethics Declaration

This research did not require formal ethical clearance as it is based solely on secondary data obtained from previously published literature. No human participants or sensitive personal information were involved in this study.

AI Declaration

The authors used OpenAI's ChatGPT (GPT-5) to assist in summarizing literature and improving language fluency.

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