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ORIGINAL ARTICLE

A Novel Business Model Canvas for Research Infrastructures: A Design Science Approach

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ABSTRACT

This paper presents the development of a novel Business Model Canvas (BMC) tailored for the unique context of publicly funded large-scale Research Infrastructures (RIs). While the standard BMC was designed for commercial enterprises, RIs operate as networked and multi-stakeholder organizational forms whose sustainability depends on legitimacy, public value, and long-term governance rather than market transactions alone. The primary purpose of the RI-BMC is to support strategic alignment and sustainability planning across heterogeneous RI stakeholders by making the infrastructure's value logic, governance dependencies, and financing model explicit; secondarily, it supports communication and legitimation toward funders and partners. Using a Design Science research methodology, we iteratively designed, prototyped, and refined an RI-specific BMC template. This process involved re-conceptualizing key components to better align with the operational realities of RIs. The resulting RI-BMC retains the familiar nine-block structure as a boundary object, while redefining block semantics and pragmatics to capture stakeholder ecosystems, involvement mechanisms, engagement intensity, and non-commercial financing opportunities. The design choices were validated through a series of stakeholder interviews, which served not only to refine the canvas's content but also as a meta-validation of its adapted structure. The resulting framework was developed within the context of GUIDE (Growing Up in Digital Europe), a pan-European RI collecting data to study children and youth well-being. We demonstrate how the adapted RI-BMC provides a coherent, holistic, and actionable strategic view that effectively bridges scientific objectives with measurable operational KPIs and sustainability planning.

Keywords: Business Model Canvas; Research Infrastructure; Design Science; Experimental Innovation; Strategic Management; GUIDE.

INTRODUCTION

For years, the Business Model Canvas (BMC) (Osterwalder and Pigneur, 2010) has been used to present the story of how organizations create, deliver, and capture value. It is a shared language that enables organizations to sketch, discuss, and innovate their business models in a clear and illustrative manner. But what happens when the "business" isn't a business in the traditional sense? What happens when the "value" isn't measured in profit, but in scientific discovery, societal progress, and evidence-based policy?

The development and sustainability of large-scale research infrastructures (RIs) are essential for addressing complex, transnational societal challenges. As these infrastructures grow in scope and ambition, so does the need for structured, flexible business models that can align operational activities with long-term strategic goals. The viability of these multi-million-euro investments depends not only on scientific excellence but also on robust governance and a clear articulation of their value to a diverse range of funders, partners, and societal stakeholders. This creates a critical need for management tools that can translate complex scientific and social value into a coherent operational and financial strategy.

The Business Model Canvas, a powerful visual framework, deconstructs an organization's value creation processes into key components. However, its standard commercial lexicon of "customers," "revenue streams," and "channels" is often ill-suited for the non-commercial, multi-stakeholder, and publicly-funded context of RIs. In business model literature, the concept has increasingly been used to analyze value creation that spans organizational boundaries, emphasizing activity systems, partnerships, and joint value creation in ecosystems, often under hybrid logics rather than purely market exchange. Research infrastructures resemble this ecosystem view: they coordinate distributed actors (hubs, nodes, partners, users, funders) and must secure legitimacy and alignment across heterogeneous stakeholders as much as they must deliver services or outputs. This motivates a canvas that represents multi-actor governance and collaboration mechanisms—not only transactional "customers" and "revenues"—and that connects the model to operational indicators suitable for public, mission-driven contexts (Zott et al., 2011).

This mismatch creates a significant research and practical gap: RIs lack a tailored strategic tool that can holistically map their unique ecosystems. This paper addresses this gap by treating the adaptation of the BMC

as an experimental innovation in strategic management, following the principles of Design Science.

In particular, we address the following research question: *How can the Business Model Canvas be adapted to effectively capture the value creation, delivery, and sustainability model of a pan-European Research Infrastructure?* To answer this, we employed a Design Science research approach to develop and test a novel, RI-specific BMC template. In this manuscript, the RI-BMC is treated as a normative artefact intended to guide strategic conversations and organizational choices (rather than merely describing them). Its primary purpose is to support strategic alignment and sustainability planning across heterogeneous RI stakeholders; secondarily, it supports communication and legitimation toward funders, partners, and the broader public. The artifact is intended for use by scientific leadership, RI managers, funders, and national node coordinators.

We demonstrate its utility for the GUIDE (Growing Up in Digital Europe) project, a pan-European RI designed to collect and analyze longitudinal data on children and young people. The outcome is a tangible and replicable framework that other RIs can adopt to navigate their strategic planning and stakeholder engagement challenges.

THEORETICAL BACKGROUND

The Business Model Canvas (BMC), originally developed by Osterwalder and Pigneur (2010), serves as a strategic management tool designed to facilitate the structuring of business models across various sectors, including the realm of research infrastructures. The BMC deconstructs business models into nine fundamental components: Customer Segments, Value Proposition, Channels, Customer Relationships, Revenue Streams, Key Resources, Key Activities, Key Partnerships, and Cost Structure. RIs, which encompass entities such as laboratories, data repositories, and collaborative networks, require robust and dynamic business models to achieve long-term sustainability and strategic alignment with institutional goals. Therefore, the BMC may provide a structured framework to enhance the understanding of how RIs create, deliver, and capture value, allowing for a more nuanced analysis of their operational dynamics.

Osterwalder's foundational work (2004) lays the essential theoretical groundwork for the BMC, positioning it as a versatile framework adaptable to an array of sectors. In "Business Model Generation" (2010), Osterwalder and Pigneur further elucidate the BMC as a practical instrument for fostering innovation and strategic planning, particularly in collaborative environments where diverse expertise converges. The inherent flexibility of the BMC empowers users to customize it according to their specific organizational contexts, making it especially beneficial for navigating the complexities of the research landscape.

Recognizing this versatility, scholars and practitioners have increasingly adapted the BMC for non-commercial contexts. Silva and Cardoso (2019) made a significant contribution by adapting the BMC specifically for research projects, emphasizing critical elements such as research objectives, anticipated outcomes, and stakeholder engagement strategies. This tailored approach highlights the versatility of the BMC and demonstrates how it can be instrumental in defining the specific objectives of a research endeavor, ensuring that all stakeholders share a clear understanding of the project's goals and expectations. However, a large-scale RI, such as GUIDE, represents a distinct organizational form — a permanent entity operating within a non-market, multi-stakeholder ecosystem more akin to a project. Research infrastructures differ from commercial firms in their governance and value-creation logics. They typically operate as distributed networks (e.g., hub-and-nodes arrangements) that depend on collaborative partners, multiple public funders, and legitimacy within scientific and policy communities. Their "value" therefore takes the form of public and scientific outcomes—data, knowledge, standards, capacity building, and policy relevance—rather than customer transactions alone. This aligns many RIs more closely with value network configurations than with linear value chains (Stabell & Fjeldstad, 1998).

This organizational form motivates the centrality of stakeholder ecosystems, engagement mechanisms, and non-commercial finance and opportunity structures in the RI-BMC. These structural traits necessitate a shift from transaction-centric modeling to ecosystem-centric modeling, with an adaptation that moves beyond the project-level focus to address long-term sustainability.

Vogel et al. (2018) further emphasize the vital role of structured business models in ensuring both sustainability and operational efficiency within RIs. By employing the BMC, organizations can effectively manage resources, identify key partnerships, and streamline core activities, ultimately enhancing their productivity and impact. Furthermore, a well-defined business model is crucial for embedding the principles of Responsible Research and Innovation (RRI), as advocated by initiatives such as the RRI Tools Project (2014-2016). By forcing an explicit consideration of all stakeholders and the societal value proposition, a structured framework like the BMC ensures that ethical considerations and societal impact are at the forefront of an RI's strategy. Projects like Transval-EU (2021) and platforms such as HEInnovate serve as practical examples of the BMC's utility in addressing challenges like securing sustainable funding and enhancing stakeholder engagement, illustrating its growing relevance in this field.

Business model tools can be understood as modeling languages whose design choices shape what is made visible and actionable. Prior work distinguishes between the semantics (the meaning of model elements), the syntax (the structure and visual form), and the pragmatics (how a model is used and interpreted in practice). In the

context of the BMC, adaptation to a new domain is therefore not only a matter of relabeling components; it also concerns whether the overall structure is suitable for its intended purpose and whether the tool supports the intended tasks of its users (Szopinski et al., 2022).

METHOD AND DATA

To develop a novel BMC for Research Infrastructures, this study employed a Design Science (DS) research methodology (Romme, 2023). DS is particularly suited for this task as it operates at the interface of creative design and explanatory science to create and test innovative solutions, or "artifacts," such as management tools. Our process followed the iterative DS cycle of theorizing, creating a solution, testing it, and refining it based on the feedback received.

The development process was structured according to the following timeline:

1. **Theorizing via Literature Review (Early May 2024):** The process began by theorizing the core problem—the inadequacy of the standard BMC for RIs—by conducting a systematic review of the literature. This foundational step involved examining existing adaptations of the BMC for non-commercial and research-oriented contexts to identify common challenges, best practices, and the specific research gap that a new RI-focused artifact could address.

2. **Developing Design Propositions and requirements (Late May 2024):** Informed by the literature review, we formulated initial design propositions. The primary proposition was that a successful adaptation required a shift in lexicon from commercial to collaborative terminology. This led to the initial design work focusing on redefining the central Value Proposition of an RI like GUIDE and identifying its key Stakeholders, moving beyond the concept of "customers". To ensure the RI-BMC functions as a normative artifact, we established explicit design requirements grounded in the context of use and applied them as evaluation criteria in alpha-testing:

Table 1. Design Requirements.

ID	Requirement	Rationale / Grounding
R1	Represent multi-stakeholder ecosystems	RIs are network-centric, not transaction-centric.
R2	Support distributed governance	Must capture the interplay between central hubs and national nodes.
R3	Make financing logic visible	RIs rely on public grants and in-kind resources, not commercial sales.
R4	Retain syntactic familiarity	Retention improves usability and supports "boundary object" functionality across diverse audiences.
R5	Enable operational evaluation	Abstract categories must be paired with measurable indicators and KPIs.

3. **Creating the Solution (Early June 2024):** Based on these propositions, the team addressed other key areas, such as Cost/Revenues, and created a First Prototype of the adapted RI-BMC on June 10, 2024. This prototype integrated new terminology and a structure deemed more appropriate for an RI, such as renaming "Customer Segments" to "Stakeholders" and "Revenue Streams" to "Finance and Opportunities".

4. **Alpha-Testing and Refinement (Mid-June 2024):** The prototype underwent an "alpha-test" through a series of planned interviews with GUIDE project colleagues and relevant external stakeholders between June 12 and June 21, 2024. These consultations served a dual purpose: they were designed to validate the *content* of the canvas while simultaneously serving as a *meta-validation* of its adapted *structure*, confirming that the adapted blocks prompted the necessary strategic conversations regarding competition, principles, and stakeholder scope. Alpha-testing interviews and internal workshops were used to assess (i) comprehensibility across heterogeneous stakeholders, (ii) perceived completeness and relevance for core RI decision tasks, and (iii) actionability—i.e., whether teams could derive concrete initiatives and plausible indicators from each block. Feedback was used to iteratively refine both the block semantics and the operationalization guidance.

5. **Structural Validation:** The overall structure was explicitly praised for its clarity and replicability. Researchers from Manchester Metropolitan University noted, *"I think the structure is really good. And it's really clear. And I think the partners who see the presentation will be able to sort of see where each better structure for this applies to their national situation"* (Interview, 12/06/2024). This

confirmed the design goal of creating a scalable model.

6. **Stakeholder Refinement:** The adapted Stakeholders block proved effective. It prompted the inclusion of Children and Youth as a distinct group, with a Senior Research Associate based at the Policy Evaluation and Research Unit (PERU) of the Manchester Metropolitan University observing that acknowledging children themselves as direct stakeholders reinforces the legitimacy and relevance of the initiative, since their inclusion naturally generates broader stakeholder engagement and institutional support (Interview, 12/06/2024). It also led to a strategic broadening of the definition of "Scientists" to include health and behavioral sciences, as a Senior Research Fellow at University College Dublin suggested, to strengthen the sustainability of GUIDE's Key Proposition and make it more resilient to potential funding fluctuations or economic downturns (Interview, 10/06/2024).

7. **Sharpening the Key Proposition:** The Key Proposition block forced a crucial discussion on competitive positioning. The GUIDE Project Manager stressed that in countries with existing longitudinal surveys, GUIDE is *"competing, frankly, against national longitudinal cohort surveys"* (Interview, 10/06/2024). This insight, prompted by the canvas's structure, led to strategic emphasis on cross-national comparability as GUIDE's unique value.

8. **Revising the Financial Model:** The most critical feedback emerged from the Finance and Opportunities block. An initial "freemium" model was strongly rejected. A social scientist from the University of Bologna stated, "*This leaves me perplexed because in this historical phase in the field of data science, we are moving towards open data... it could be a critical point"* (Interview, 19/06/2024). This feedback, directly tied to the adapted block, was pivotal in realigning the financial model with Open Data principles and focusing on value-added services instead.

9. **Finalizing the Artifact (Late June - Early July 2024):** The feedback from the alpha-testing phase was used to create a second, more robust draft and finalize the methodology. The resulting artifact—the general RI-BMC template—was then reviewed by GUIDE project partners, serving as a final validation step.

RESULTS

The primary result of this Design Science process is the creation of a novel, generalized Business Model Canvas template specifically adapted for Research Infrastructures. This RI-BMC, presented in Figure 1, is the direct outcome of the iterative design and stakeholder validation process. It modifies five of the nine original BMC blocks and incorporates the nuanced feedback received during alpha-testing.

The key adaptations, refined through stakeholder consultation, are:

- **From Customer Segments to Stakeholders:** The term "customers" implies a transactional relationship, which is inadequate for describing the diverse actors in an RI's ecosystem. Stakeholders is a more inclusive term that captures the ecosystem composed of a wide range of entities—such as policymakers, scientists, advocacy groups, and the public—that both contribute to and benefit from the RI's activities and data.
- **From Value Proposition to Key Proposition:** RIs deliver value that is often social, scientific, and political rather than a commercial product or service. Key Proposition better reflects this multifaceted value, which includes providing unique data for evidence-based policy, enabling international scientific collaboration, and informing public discourse.
- **From Channels to Involvements:** The concept of "channels" typically refers to the delivery of a product to a customer. For an RI, interaction is more collaborative and participatory. Involvement describes the various ways stakeholders actively engage with the RI, such as through academic publications, policy briefings, or direct participation in advisory boards, rather than passively receiving a service.
- **From Customer Relationships to Intensity:** The nature and frequency of engagement vary dramatically among different stakeholder groups. Intensity was chosen to define the cadence and depth of these interactions, distinguishing between, for example, the continuous data access required by researchers and the annual high-level reporting provided to policymakers.
- **From Revenue Streams to Finance and Opportunities:** RIs are typically funded through a complex mix of public grants, institutional contributions, and strategic partnerships, not commercial revenue. Finance and Opportunities provides a more accurate framework for mapping these diverse and often non-transactional funding sources, including in-kind contributions and potential sponsorships.

The Research Infrastructure Business Model Canvas (RI-BMC) in Figure 1 retains the holistic, nine-block, well-known structure, but it modifies the vocabulary to reflect the unique reality of RIs. It shifts the focus from transactional customers to a collaborative network of stakeholders, and from revenue streams to financing and opportunities.

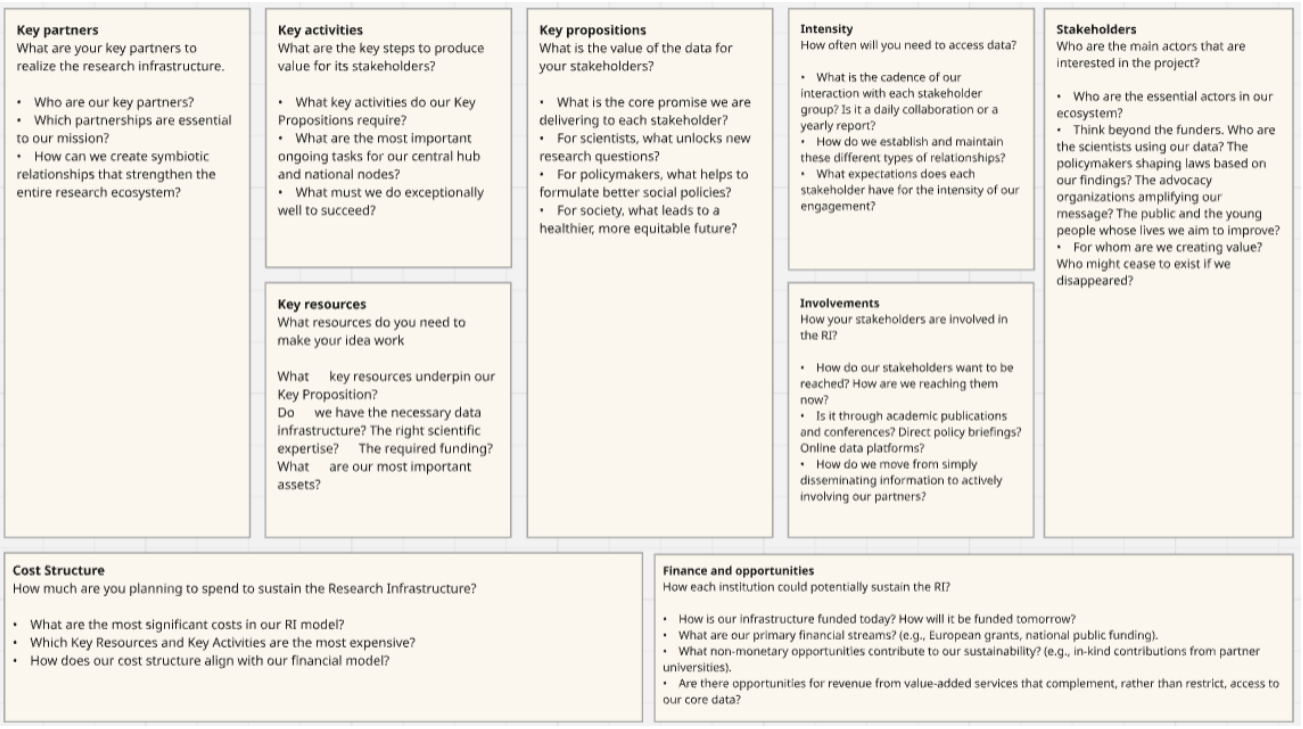

Fig. 1. Research Infrastructure BMC

Let's walk through the nine building blocks that are useful for representing a Research Infrastructure. Just as the original, the RI-BMC is best understood by examining its interconnected components. We'll start on the right, focusing on the created value and the served community, before moving to the operational and financial foundations.

1. Stakeholders

A Research Infrastructure serves a diverse ecosystem of actors who are both beneficiaries and co-creators of value. That's why we start with Stakeholders. This block is about identifying all the different people and organizations you create value *for* and *with*. An RI is like a public square, not a private shop. Many different groups gather there, each with its own needs and contributions.

2. Key Proposition

Once you know your stakeholders, you must articulate what you offer them. For an RI, the value is often broader and more profound than a single product. It's a promise of discovery, a tool for societal advancement, and a foundation for future knowledge. We call this the Key Proposition. It's the fundamental promise you make to each stakeholder group. It's not just a bundle of features; it's the core reason your RI exists.

3. Involvements

How do you connect your Key Proposition to your Stakeholders? RIs engage their community in a continuous, collaborative dialogue. This is why we use the term Involvement. This block describes the touchpoints through which you and your stakeholders interact and co-create. It's not a one-way street; it's a network of relationships.

4. Intensity

For an RI, the way it interacts with a core research team differs significantly from how it reports to a government funding agency. We use the term Intensity to capture the frequency, depth, and nature of these different relationships. Think of it as a rhythm. The beat of your interaction with scientists might be continuous and dynamic, while the rhythm of your engagement with policymakers might be annual and formal.

5. Finance & Opportunities

Now we turn to the financial foundation. RIs are typically sustained by a complex mix of funding sources,

rather than direct sales. This portfolio showcases the diverse financial mechanisms that ensure your long-term sustainability, including public grants, institutional contributions, strategic partnerships, and in-kind resources. It also encourages you to think beyond direct funding to value-added services, such as specialized training workshops, that align with your mission.

6. Key Activities

To make your model work, you must perform a set of crucial activities. This block remains unchanged in name but is vital for an RI. These are the most crucial steps you must take to deliver your Key Proposition and maintain your relationships. For an RI, these activities are not manufacturing or marketing. These include conducting longitudinal surveys, harmonizing complex data, managing stakeholder engagement, and ensuring rigorous ethical compliance.

7. Key Resources

Key Activities require Key Resources. Again, the name is the same, but the context is everything. RI's most critical resources are often intangible. They include the data itself, the standardized methodologies, the human capital of skilled researchers and data scientists, and the legal and ethical frameworks that build trust.

8. Key Partners

Few RIs can go alone. They are built on a network of partnerships. This block is about the web of collaborators that make your model work. These aren't just suppliers; they are integral parts of your value creation process. For an RI, key partners include universities and research centers, national survey agencies, government bodies, and even other RIs.

9. Cost Structure

Finally, all the elements of the model manifest in the Cost Structure. This block outlines all the costs associated with operating your business model. For an RI, these costs are substantial and unique, including expenses for preliminary pilot studies, waves of interviews, participant incentives, and the operational costs of both the central hub and the national nodes.

The Research Infrastructure Business Model Canvas serves as an invaluable framework for facilitating strategic discourse within research organizations. It transcends the traditional role of a mere visual representation; rather, it functions as a comprehensive tool that enables stakeholders to appreciate the interconnectedness of their scientific objectives, operational methodologies, and financial viability.

To leverage this tool effectively, it is recommended that teams convene for collaborative sessions. Printing the canvas on a large poster provides a tangible focal point for discussion. Utilizing sticky notes and markers enables team members to actively engage in the brainstorming process, fostering a dynamic environment where assumptions can be questioned and reevaluated.

This canvas not only assists in articulating a coherent and persuasive narrative for various stakeholders, including funders, partners, and policymakers, but also promotes the development of a shared vocabulary that enhances collective comprehension. By cultivating this shared understanding, research institutions can lay the groundwork for a sustainable and impactful research infrastructure, ultimately advancing their scientific missions.

The following table presents the general version of the adapted RI-BMC, populated with the high-level components relevant to the GUIDE research infrastructure at a European level.

GUIDE is implemented as a pan-European, distributed research infrastructure that combines a central coordinating hub with multiple national nodes. The hub orchestrates methodological design, harmonization protocols, repository infrastructure, and access governance, while national nodes implement recruitment, fieldwork, and local stakeholder engagement in line with shared standards.

Operationally, GUIDE can be described as a recurring cycle of activities: (i) instrument and wave design; (ii) ethical and legal compliance; (iii) coordinated data collection across nodes; (iv) data harmonization, quality assurance, and FAIR-oriented documentation; (v) controlled data access for the scientific community and other legitimate users; and (vi) dissemination and dialogue with policy, practice, and advocacy stakeholders. These steps define the practical touchpoints where the RI-BMC supports alignment of responsibilities, dependencies, and expectations.

In addition to describing GUIDE's high-level instantiation, we add an operationalization layer: for each block, we propose GUIDE-specific measures (direct KPIs, proxies, or qualitative evidence) to support both planning and evaluation. Table 2 links each RI-BMC block to GUIDE-specific operationalizations and candidate indicators. We explicitly discuss blocks that require proxy or qualitative evaluation in the Discussion.

This general canvas provides a structured and scalable tool that can be tailored by different national nodes or other RIs, demonstrating the practical utility of the artifact created through our design process.

Table 2. The Adapted Business Model Canvas for the GUIDE Research Infrastructure.

Adapted block	Application to GUIDE (European Level)	Possible indicators/tools to operationalise impact/performance
Stakeholders	European & National Policymakers; Researchers (Social, Health, Behavioural); Educational Institutions; Child & Youth Advocacy Organizations; Children, Youth & Families; Service Providers (Health, Social); Private Sector & Philanthropy.	Mapping and Number of European and National policymakers involved in welfare policies (potential reach); Mapping and Number of European and National researchers in the field of children's well-being (potential reach); Mapping and Number of European and National child and youth advocacy organisations (potential reach); Mapping and Number of European and National private and philanthropic institutions involved in child well-being (potential reach); Number of families/children participating in the survey (nationally and in total); Number of children participating in the youth advisory groups (nationally and in total); Number of engagement events/year; Stakeholder satisfaction.
Key Proposition	Provision of high-quality, cross-nationally comparable, longitudinal data to support evidence-based social policies; Fostering innovation in research; Enabling stakeholder collaboration; Empowering the voice of children and youth.	Activity Report from central hub and national nodes (revised annually); Scientific report (Survey methods and data collection/repository) (revised annually); Communications and engagement report (annual) related to the activities and events carried out with stakeholders (see also Involvement); Governance and ethical report (revised annually); Number of families/children participating in the survey (nationally and in total); Number of children participating in the youth advisory groups (nationally and in total); Number and typology of online data access and user platforms; Uptake of accessible data set outside the RI; Number and typology of people reached and engaged in outreach activities; Number of HE students trained using RI; Provision of expert advice in public policy; Provision of empirical data in support of public policy; Scientific collaboration with other RIs (joint projects).
Involvements	Academic publications and reports; Secure online data access platforms; Policy briefings and workshops; Newsletters and press releases; Stakeholder consultations; Public engagement through media and events.	Number and type of academic publications and reports related to GUIDE; Number and typology of online data access and user platforms; Number of briefings and workshops; Number of newsletters and press releases; Number of events held in relation to stakeholders and public consultations (and number of people participating); Number of capacity building and training events (and number of people participating); Number of visitors of website and followers on social media; Number of policy briefings citing GUIDE.
Intensity	Continuous engagement with the scientific community; Regular reporting to policymakers and funders; Technical and methodological support for data users; Capacity building and training events; Active collaboration with advocacy partners.	Communications and engagement report (annual) related to the activities and events carried out (see also Involvement)
Finance and Opportunities	European and national public funding; In-kind contributions from partner institutions; Strategic partnerships and sponsorships; Revenue from value-added services (training, workshops, custom reports); Joint ventures with existing national surveys.	Financial plan (revised annually) reporting on costs incurred and resources obtained from various sources and partnerships; Scientific collaboration with other RIs (in terms of joint proposals submitted/won); Funding mix (% EU/national/in-kind/service).
Key Resources	A central coordinating hub; National nodes for implementation; Secured funding; Qualified personnel for coordination and data management; Standardized methodologies and survey instruments; A secure, FAIR-compliant data repository; Legal and ethical frameworks.	Activity Report from central hub and national nodes (revised annually); Human resource report (revised annually) with the number of people employed in RI (FTE) (scientific and technical); Scientific report (Survey methods and data collection/repository) (revised annually); Governance and ethical report (revised annually); Compute/storage capacity.
Key Activities	Conducting the longitudinal study across multiple waves; Data collection, processing, and harmonization; Management and coordination of the consortium; Stakeholder engagement and communication; Development of training materials and tools.	Activity Report from central hub and national nodes (revised annually); Scientific report (Survey methods and data collection/repository) (revised annually); Wave schedule adherence; Communications and engagement report (annual) related to the activities and events carried out (see also Involvement); Management report about GUIDE consortium (revised annually); Number of HE students trained using RI; Scientific collaboration with other RIs (joint projects).
Key Partners	Universities and Research Centers; ESFRI (European Strategy Forum on Research Infrastructures); National Survey Agencies; Government Agencies; NGOs and Advocacy Groups; Existing National Cohort Studies; Youth Advisory Boards.	Number of formal agreements/MoUs; partner retention; Number of joint outputs/projects; Activity Report from central hub and national nodes (revised annually); Human resource report (revised annually); Scientific report (Survey methods and data collection/repository) (revised annually); Management report about GUIDE consortium (revised annually); Governance and ethical report (revised annually).
Cost Structure	Annual spending required to sustain hub and node operations.	Annual OPEX/CAPEX; Cost per participant/respondent; Cost per wave; Management report about GUIDE consortium (revised annually).

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DISCUSSION AND CONCLUSIONS

The Design Science approach proved highly effective for developing a strategic tool tailored to the specific needs of Research Infrastructures. The iterative process of prototyping and alpha-testing with stakeholders was crucial. The interviews provided not only a validation of the canvas's content but also a meta-validation of its adapted structure. The quality and nature of the feedback—spanning strategic discussions on competition, funding models, and stakeholder scope—demonstrated that the adapted canvas successfully prompted the right conversations for an RI. This was best articulated by a senior researcher in applied statistics with a focus on population data, education, and gender studies of CNR (Italian National Research Council), who noted that the process of reviewing an imperfect draft is valuable in itself, as *"this induction to reasoning due to imperfection... is certainly important also, that is, imperfection is not necessarily a defect"* (Interview, 21/06/2024). This highlights how the RI-BMC artifact, even as a prototype, functioned effectively as a tool for critical reflection and co-creation.

RI-BMC also implies that some desired outcomes (e.g., empowerment or collaboration) may require mixed evaluation approaches that combine quantitative signals with qualitative evidence. Drawing on the literature of Business Model Modeling Languages (Szopinski et al., 2022), we analyze the RI-BMC across three dimensions:

- Semantics: The meaning and vocabulary assigned to each block (e.g., reframing "Customers" as "Stakeholders" to reflect the diverse range of entities that contribute and benefit).
- Syntax: The visual form and structure. We intentionally maintain the canonical nine-block format to leverage its familiarity and ensure high "cognitive fit" for users across scientific and administrative fields.
- Pragmatics: The context and protocol of use. This includes how the language is used in practice, such as in collaborative workshops to identify strategic tensions.

Following this lens, we retain the familiar nine-block syntax of the canonical BMC to preserve usability and the boundary-object function across scientific, managerial, and policy audiences, while substantially revising semantics and pragmatics for the RI setting. In particular, we complement definitional changes with an operationalization layer that links each block to evaluable indicators, strengthening the tool's normative role in strategizing and learning cycles (Baden-Fuller & Morgan, 2010).

The primary conclusion of this study is that the adapted RI-BMC is a valuable and replicable innovation in the strategic management of RIs. The Design Science process revealed that for RIs, the core innovation lies in shifting from transaction-centric modeling to ecosystem-and-legitimacy-centric modeling. Beyond simple terminology changes, the artifact introduces an operational KPI layer that bridges the gap between scientific abstraction and management rigor. By reframing the right part of the BMC, we provide a shared vocabulary that facilitates alignment between the scientific and administrative bodies necessary for RI success.

Because the RI-BMC is intended as a normative tool, its usefulness depends on whether teams can translate blocks into actions and assess progress over time. Our GUIDE application suggests three broad cases. First, several blocks lend themselves to direct operational metrics (e.g., Key Activities, Key Resources, Cost Structure, and parts of Finance & Opportunities), because they map to observable workflows, budgets, capacity, and deliverables.

Second, other blocks can be operationalized through proxies and process indicators rather than single outcome metrics (e.g., Stakeholders, Involvements, and Intensity). Here, indicators such as the frequency and diversity of engagement activities, timeliness of responses, or documented decision traces can support evaluation without forcing complex social phenomena into overly simplistic measures.

Third, some elements—such as "enabling stakeholder collaboration" or "empowering the voice of children and youth"—remain partly normative and value-laden. For these, GUIDE can combine proxy signals (e.g., representation in advisory structures, the extent to which input is incorporated into instruments or governance decisions) with qualitative evidence (e.g., reflective logs, independent stakeholder feedback, and documented changes attributable to youth consultation). This explicitly qualifies which dimensions are immediately measurable and which remain in the realm of abstract guidance, indicating where additional methodological work is needed. It addresses the fundamental challenge of articulating a non-commercial value proposition within a robust operational and financial plan. The canvas acts as a powerful "boundary object", a common language that facilitates structured dialogue and alignment between the scientific, administrative, and funding bodies that must work in concert for an RI to succeed. It is a dynamic tool for managing the inherent tensions within an RI, such as balancing central coordination with national autonomy, or articulating both the long-term scientific value and the short-term policy relevance. The process revealed that a key strategic imperative for GUIDE is to partner with existing national cohort studies, perhaps by having *"guide questions as part of the existing survey,"* rather than creating a competing infrastructure from scratch (Interdisciplinary researcher in education, wellbeing, and public policy at the University College Dublin, Interview, 10/06/2024,).

This experimental application opens several avenues for future research and practice. Beyond adapting

terminology, the main Design Science insight is that RIs require a canvas that foregrounds ecosystem governance and legitimacy, and that couples the canvas to an explicit operationalization layer. In our case, the novelty lies in (i) reframing the right-hand side of the classical BMC around Involvements and Intensity (rather than market channels and customer relationships) and (ii) replacing revenue-centric logic with Finance & Opportunities suitable for publicly funded infrastructures. The GUIDE demonstration shows how this reframing supports both strategizing and evaluation, while also clarifying where future work is needed (e.g., shared measurement protocols and, potentially, alternative visual forms for highly networked RIs). The model is designed to be scalable, providing a consistent framework that can be adopted by all national partners within the GUIDE consortium, thereby strengthening the governance of the entire European infrastructure. Future research could involve applying and comparing the RI-BMC across different types of RIs to test its versatility and value. It could also test different forms of visualization to support highly networked RIs or ecosystems. Furthermore, the RI-BMC could be used as a longitudinal tool to track and manage strategic pivots in response to evolving funding landscapes or policy priorities. Finally, the framework has significant potential as a pedagogical tool in university programs or at innovation hubs like CERN IdeaSquare, training the next generation of RI managers in the principles of strategic management. While this study is based on a single, albeit rich, case study, its findings provide an initial foundation and a practical instrument for enhancing the strategic planning, sustainability, and societal impact of research infrastructures.

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CONFLICTS OF INTEREST

Matteo Vignoli is the Editor-in-Chief of CERN Ideasquare Journal of Experimental Innovation and a co-author of this article. Prof. Vignoli was excluded from all editorial decision-making and peer-review management related to this manuscript. All other authors declare that they do not have conflicts of interest.

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APPENDIX A - GUIDE

GUIDE (Growing Up in Digital Europe) is a research infrastructure to implement a longitudinal survey that focuses on the well-being of children and young people across Europe (and it is included in the European Strategy Forum for Research Infrastructures (ESFRI) 2021 roadmap). GUIDE is a distributed research infrastructure in the preparatory phase, and 20 countries are currently participating: Austria, Belgium, Croatia, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, Norway, Malta, Portugal, Slovakia, Slovenia, Spain, and the UK. GUIDE has a central hub, coordinated by UCD (Ireland) and Manchester Metropolitan University (UK), and national nodes (managed by national partners, which are responsible for the implementation of the survey, also financially, in their country).

The survey will involve two cohorts of children (statistically representative of the corresponding population in each country):

-C1 cohort (children aged 8). Age 8 cohort will be interviewed for the first time in 2028, with follow-up interviews every three years. Therefore, the age 8 cohort will have follow-up interviews at ages 11-12 (during these two waves, both one parent and the child will be interviewed), 14-15, 17-18, 20-21, and 23-24 (in these subsequent waves, only the young person will be interviewed). The size of the cohort will be 8,000 children in large countries (with a population above 10 million people) and 4,000 children in small countries (with a population below 10 million).

- C2 cohort (infants aged 0-1). Age 0 cohort will be interviewed for the first time in 2030 with follow-up interviews at ages 2-3, 5-6 (in these first three waves, only one parent will be interviewed), 8-9, 11-12, 14-15, 17-18, 20-21, and 23-24 (as in C1 cohort). The initial cohort size will be 10,000 children in large countries (with a population above 10 million people) and 5,000 children in small countries (with a population below 10 million).

In the years 2023-25, nine countries (Ireland, France, Finland, Croatia, Slovenia, Italy, Norway, UK and Denmark) have conducted pilots to test the questionnaires for the C1 cohort.

The socio-economic impact of GUIDE can be grouped into three areas (see Florio (2019) and Ecchia, O'Leary, and Messori (2021)):

- Value and Efficiency Gains for Researchers: a European infrastructure collecting and analyzing data on child well-being will enhance research efficiency and encourage international and interdisciplinary collaboration.
- Knowledge Output**:** the longitudinal data made available by GUIDE will significantly expand the understanding of child well-being across Europe.
- Human Capital and Welfare Policies**:** GUIDE will provide policymakers with data needed to better understand the causal relations between socio-economic conditions of children and socio-economic achievements, enabling the design of interventions/policies that foster the development of human capital from early childhood and improve child well-being.