American Journal of Advanced Multidisciplinary Innovation and Research (AJAMIR)

E-ISSN: XXXX-XXXX • Website: www.ajamir.com • Email: editor@ajamir.com

Lean Experimentation for Public-Interest Technology Startups

Dr. Farid A. Mohamad

Professor, Universiti Malaysia Sarawak, Malaysia

Abstract

Public-interest technology startups operate at the intersection of entrepreneurial uncertainty and societal responsibility. They may develop technologies for civic participation, public-service accessibility, health, education, environmental monitoring, community infrastructure, administrative efficiency, or other socially consequential domains in which conventional startup experimentation can affect individuals who are not merely customers but citizens, patients, students, beneficiaries, or members of vulnerable communities. This study examines how lean experimentation can be adapted to these conditions without abandoning either rapid learning or public accountability. Lean experimentation is conceptualized as a disciplined process of converting assumptions into testable propositions, implementing proportionate experiments, collecting decision-relevant evidence, and revising products or business models before excessive resources are committed. Existing entrepreneurship research supports experimentation and scientific hypothesis testing as mechanisms for reducing uncertainty, while responsible-innovation and public-value scholarship emphasizes anticipation, inclusion, reflexivity, responsiveness, accessibility, and societal outcomes.

Because no primary startup dataset was supplied, the present study employs a simulation-based explanatory design. Five synthetic scenarios representing lean-experimentation maturity from 20% to 100% were evaluated through validated-learning efficiency, public-value alignment, stakeholder inclusion, ethical safeguard integration, resource efficiency, and mission continuity. Simulated validated-learning efficiency increases from 48 to 90 and public-value alignment from 43 to 89 across the scenarios, while avoidable experimentation risk decreases from 76 to 30. The study argues that minimum viable products in public-interest technology should be minimum in scope, not minimum in responsibility. Privacy, accessibility, fairness, informed participation, safety, and foreseeable public harms require consideration from the earliest experiment when materially relevant. The resulting framework extends lean startup logic from customer validation toward responsible validated learning, in which evidence about desirability and feasibility is considered alongside public value, inclusion, and ethical acceptability.

Keywords: lean experimentation, public-interest technology, lean startup, civic technology, responsible innovation, public value, validated learning, startup experimentation

1. Introduction

Startups operate under substantial uncertainty concerning user needs, technological feasibility, adoption, pricing, organizational capability, and the structure of future markets. Lean startup approaches emerged in response to this uncertainty by challenging business-development models in which entrepreneurs make large commitments before testing central assumptions. Blank characterizes lean startup practice through rapid customer-oriented learning and iterative business-model development, while Contigiani and Levinthal describe lean startup as an experimentation-driven entrepreneurial approach closely connected with organizational learning, search, product development, and strategic adaptation. The resulting logic is attractive because it treats uncertainty as something entrepreneurs should investigate through structured evidence rather than conceal beneath detailed but weakly validated forecasts.

Empirical entrepreneurship research increasingly supports the underlying principle that structured experimentation can improve the quality of entrepreneurial learning. Camuffo, Cordova, Gambardella, and Spina conducted a randomized controlled trial involving 116 Italian startups and found that training entrepreneurs to formulate hypotheses and test them systematically affected entrepreneurial decision processes. Ghezzi likewise found that digital entrepreneurs applying lean startup approaches use business models as cognitive devices for translating broad methodological principles into fast and frugal heuristics, while Mansoori, Karlsson, and Lundqvist demonstrated that lean startup methodology can influence learning relationships within startup accelerators. These findings provide a strong foundation for treating experimentation as an entrepreneurial capability rather than an informal sequence of product trials.

Public-interest technology creates an additional challenge because the people affected by an experiment may possess interests that extend beyond ordinary consumer satisfaction. Civic technologies, for example, can influence public participation, information access, deliberation, government interaction, and the distribution of visibility or voice. Gilman's research on civic technology highlights pathways through which technology may contribute to collaborative governance, while Lukensmeyer emphasizes the potential role of civic technology in public-policy decision making and large-scale public participation. A technology startup operating in such settings must therefore ask not only whether people will use a product but whether its design supports legitimate public purposes and avoids systematically excluding or disadvantaging particular groups.

This wider responsibility is consistent with responsible-innovation scholarship. Stilgoe, Owen, and Macnaghten propose a framework centered on anticipation, reflexivity, inclusion, and responsiveness as important dimensions of responsible innovation. Public-value research likewise demonstrates that digital government technologies may be judged through outcomes extending beyond transactional efficiency, including improved public services, administrative effectiveness, openness, ethical conduct, and broader social value. Twizeyimana and Andersson's review of public value in e-government identified multiple dimensions through which digital technologies may create value for society. Consequently, experimentation in public-interest technology cannot responsibly use commercial traction as its only validation criterion.

The present study develops the concept of Lean Experimentation for Public-Interest Technology Startups by integrating entrepreneurial experimentation with responsible innovation, civic technology, and public-value perspectives. It argues that public-interest startups should retain the advantages of rapid hypothesis testing while modifying what counts as a valid experiment and what evidence is required before scaling. Because no real startup, citizen, government, nonprofit, or community dataset was supplied, the quantitative component is explicitly simulated. The objective is to create a theoretically grounded model in which learning speed, public value, inclusion, ethical safeguards, and resource discipline can be examined together rather than treating responsibility as a constraint applied only after product-market validation.

2. Objectives of the Study

2.1 To Reframe Lean Experimentation Around Responsible Validated Learning

The first objective is to extend validated learning beyond the conventional question of whether a user problem, product proposition, or business-model assumption is supported by evidence. Frederiksen and Brem's examination of lean startup highlights experimentation over long-term prediction and identifies strong links with effectual entrepreneurial logic. Contigiani and Levinthal similarly position lean startup within broader research on experimentation, search, learning, and strategic adaptation. These perspectives provide a useful foundation but require additional evaluation dimensions where startup decisions may produce material public consequences.

Within the present framework, responsible validated learning requires a startup to test two broad categories of assumptions simultaneously. The first concerns conventional venture viability: whether the technology solves a meaningful problem, can be used effectively, can be delivered sustainably, and has a credible adoption pathway. The second concerns public-interest acceptability: whether the proposed solution creates recognizable public value, distributes benefits and burdens reasonably, protects relevant rights, remains accessible to intended populations, and avoids predictable harms. A public-interest experiment is therefore successful when it reduces strategically important uncertainty without generating disproportionate social, privacy, accessibility, or ethical costs.

2.2 To Examine the Interaction Between Experiment Speed and Public-Value Alignment

The second objective is to assess whether lean experimentation can theoretically improve startup learning efficiency while preserving or strengthening public-value alignment. The study rejects the assumption that public safeguards necessarily require abandoning rapid experimentation. Small, reversible, carefully scoped experiments may actually make responsible innovation easier by revealing unintended consequences before systems become deeply embedded. Stilgoe and colleagues' responsible-innovation framework is compatible with such an interpretation because anticipation and responsiveness imply ongoing reflection and adjustment rather than a single ethics assessment conducted at the end of development.

At the same time, speed is not inherently desirable. Public-interest startups may encounter situations in which the cheapest or fastest test creates unacceptable risks for participants or creates evidence that is systematically biased toward the easiest users to recruit. For example, a digital public-service prototype validated only among highly connected users may appear successful while obscuring accessibility barriers experienced by people with limited digital access. Lean experimentation must therefore optimize learning per unit of responsible exposure, rather than simply maximizing the number of experiments performed.

2.3 To Develop an Empirically Testable Framework for Public-Interest Startups

The third objective is to develop measurable constructs suitable for future research involving civic-tech, health-tech, education-tech, environmental-tech, government-tech, nonprofit technology ventures, and other mission-driven startups. The framework incorporates experimentation maturity, hypothesis clarity, stakeholder inclusion, ethical safeguard integration, validated-learning efficiency, public-value alignment, avoidable experimentation risk, and mission continuity.

Future researchers could validate these relationships through longitudinal studies of startup experimentation logs, founder interviews, user-research records, ethics-review documentation, product iterations, procurement decisions, community feedback, and organizational outcomes. The framework could also support comparative studies examining whether public-interest startups funded primarily by venture capital, philanthropy, government grants, or hybrid financing mechanisms adopt different experimentation patterns. The present paper does not claim such relationships have already been empirically established; it provides a structured basis for testing them.

3. Review of Literature

3.1 Lean Startup, Experimentation, and Entrepreneurial Learning

Lean startup thinking reframes venture development as a search process in which key assumptions should be converted into tests before irreversible commitments accumulate. Blank's widely cited account describes lean startup practice as replacing extensive initial business planning with iterative customer development and experimentation. Frederiksen and Brem's scholarly examination of the approach emphasizes its reliance on experimentation and effectual thinking, while Contigiani and Levinthal connect lean startup with adjacent theories of organizational learning, real options, product development, and technology evolution. The shared principle is epistemic: entrepreneurs should distinguish assumptions from evidence and design learning processes capable of updating those assumptions.

Camuffo and colleagues provide especially important experimental evidence. Their randomized controlled trial examined a more scientific entrepreneurial decision approach based on explicit theories, hypotheses, and tests rather than relying primarily on intuition or confirmatory search. This contribution suggests that experimentation quality depends upon more than conducting many tests. Entrepreneurs require clear assumptions, appropriate evidence, decision thresholds, and willingness to revise beliefs when data contradict prior expectations.

Implementation research also shows that lean startup is socially embedded. Mansoori and colleagues found that the methodology shaped entrepreneur–coach relationships in accelerator settings and facilitated forms of learning while also creating tensions between customer evidence and perceived coaching authority. Ghezzi's study of digital startups similarly shows that entrepreneurs require cognitive frameworks capable of turning abstract lean guidance into usable decision heuristics. These findings imply that lean experimentation should be evaluated as an organizational learning system, not merely a product-development technique.

3.2 Public-Interest Technology, Civic Participation, and Public Value

Public-interest technology has no single venture form. It may involve software supporting civic participation, digital public services, accessibility, community information, health systems, educational access, environmental monitoring, regulatory compliance, or other functions connected with collective welfare. Civic-tech research provides an especially relevant early evidence base. Gilman's study examines civic technology as a mechanism for collaborative urban governance and identifies pathways through which digital tools can strengthen participation and relationships among public actors. Lukensmeyer similarly argues that civic technology can contribute to public-policy decision making but emphasizes the need for institutional support and scale if such technologies are to address significant policy problems.

These studies highlight a fundamental difference between public-interest experimentation and ordinary consumer-product experimentation. Citizens interacting with public or civic systems may not possess meaningful alternatives, and public-service outcomes may affect rights, opportunities, information access, or participation. Consequently, adoption cannot be treated as a complete measure of value. A system may achieve high usage because it is required, while remaining difficult to access, unfair, opaque, or burdensome for particular populations.

Twizeyimana and Andersson's review of e-government literature reinforces this broader interpretation by identifying several dimensions through which digital technologies can create public value. This perspective suggests that public-interest startup experiments should generate evidence not only about whether a product functions but also about whose value is being created, through which mechanism, and at what cost. Public-value hypotheses are therefore legitimate startup hypotheses and should be incorporated into experimentation rather than deferred to post-launch evaluation.

3.3 Responsible Innovation and Ethical Boundaries of Experimentation

Responsible-innovation research provides a governance lens for determining how experiments should be designed when outcomes may have societal consequences. Stilgoe, Owen, and Macnaghten organize responsible innovation around anticipation, reflexivity, inclusion, and responsiveness. Anticipation requires developers to consider plausible consequences before deployment; reflexivity requires examination of assumptions and values; inclusion requires engagement with relevant stakeholders; and responsiveness requires willingness to change direction as new knowledge emerges.

These principles are compatible with experimentation but change the definition of a good experiment. A conventional lean test may seek the fastest reliable indicator of demand. A responsible public-interest experiment must additionally consider whether the test population is appropriate, whether participants understand relevant risks, whether collected data are proportionate to the learning objective, and whether the experiment could impose harms that cannot easily be reversed. Public-interest technology therefore introduces ethical experiment design as a core entrepreneurial competence.

The resulting theoretical opportunity is not to replace lean startup with responsible innovation but to combine them. Lean startup provides mechanisms for rapidly reducing uncertainty, while responsible innovation provides criteria for determining which uncertainties matter and which experimentation boundaries should not be crossed merely for speed. Together, they support an approach in which startups learn rapidly and remain accountable for the conditions under which that learning occurs.

4. Research Methodology

4.1 Research Design and Simulation Scope

The study employs a simulation-based explanatory research design because no real startup records, public-service users, experimental participants, civic organizations, government partners, or product datasets were supplied. Every numerical value presented in the analysis is synthetic. The simulation is intended to operationalize the conceptual relationships developed from the literature without fabricating empirical respondents or claiming observed causal effects.

Five scenarios were constructed representing Lean Experimentation Maturity levels of 20%, 40%, 60%, 80%, and 100%. Higher maturity represents increasingly disciplined hypothesis formulation, smaller and more reversible experiments, stronger evidence collection, explicit decision thresholds, structured stakeholder feedback, and integration of public-interest safeguards before scaling.

4.2 Construct Operationalization and Public-Interest Safeguards

Six positive analytical constructs and one risk construct were included. Validated-Learning Efficiency represents the amount of decision-relevant uncertainty reduced through proportionate experimentation. Public-Value Alignment represents the degree to which product development remains connected to socially relevant outcomes rather than only adoption or revenue. Stakeholder Inclusion represents the breadth and quality of participation by people affected by the technology.

Ethical Safeguard Integration represents the incorporation of relevant privacy, fairness, accessibility, safety, consent, transparency, and harm-mitigation considerations into experiment design. Resource Efficiency measures whether experiments reduce uncertainty before major resource commitment. Mission Continuity represents the startup's ability to preserve its public-interest purpose while iterating its product or business model. Avoidable Experimentation Risk captures preventable exposure arising from poorly governed testing.

Table 1:Operationalization of the Responsible Lean Experimentation Framework

Construct	Operational Meaning	Measurement	Expected Direction
Lean Experimentation Maturity	Systematic use of hypotheses, proportionate tests, evidence, learning cycles, and explicit decision rules	Scenario: 20%–100%	Independent condition
Validated-Learning Efficiency	Decision-relevant uncertainty reduced relative to time and resources used	Index: 0–100	Increase
Public-Value Alignment	Degree to which experimentation remains connected with intended societal or public benefits	Index: 0–100	Increase

Construct	Operational Meaning	Measurement	Expected Direction
Stakeholder Inclusion	Meaningful involvement of affected users and stakeholders in problem definition and validation	Index: 0–100	Increase
Ethical Safeguard Integration	Incorporation of relevant privacy, accessibility, fairness, safety, and harm controls	Index: 0–100	Increase
Resource Efficiency	Avoidance of large commitments before critical assumptions receive adequate testing	Index: 0–100	Increase
Mission Continuity	Ability to pivot product or delivery mechanisms without unintentionally abandoning the public-interest mission	Index: 0–100	Increase
Avoidable Experimentation Risk	Preventable ethical, inclusion, privacy, or implementation exposure generated by weak experiment design	Index: 0–100	Decrease

Source: Author-developed simulation informed by lean startup, scientific entrepreneurial decision making, responsible innovation, civic technology, and public-value research. The experimentation component is consistent with Camuffo and colleagues' scientific entrepreneurial decision framework, while safeguard dimensions draw conceptually from responsible-innovation principles.

4.3 Simulation Procedure and Evaluation Logic

At the 20% maturity condition, experiments are assumed to be frequent but relatively weakly structured. Hypotheses are imprecise, participant recruitment follows convenience, public-value criteria remain secondary, and ethical review is largely reactive. The 40% and 60% scenarios progressively introduce explicit assumptions, structured user research, learning metrics, inclusion checks, and safeguards. The 80% and 100% conditions represent increasingly mature systems in which experimentation speed is preserved but test design includes formal attention to public consequences.

The 100% scenario does not imply a risk-free startup or perfect ethical performance. Innovation necessarily contains uncertainty, and not every unintended consequence can be anticipated. Instead, full simulated maturity represents the strongest modeled capacity to identify foreseeable risks, learn proportionately, document evidence, and stop or redesign experiments when evidence indicates that continuation is unjustified.

Evaluation is descriptive rather than inferential. P-values, confidence intervals, population estimates, or causal regression coefficients are intentionally excluded because the scenario values were constructed rather than observed. The analysis therefore focuses on theoretical coherence, directional relationships, and the conceptual trade-offs that future empirical research could test.

5. Analysis

5.1 Development of Responsible Experimentation Capability

The simulation indicates a progressive shift from high-risk experimentation toward more responsible and inclusive startup learning. Avoidable Experimentation Risk remains high at 76, representing a startup that conducts rapid tests but lacks sufficient discipline to determine whether the evidence collected is socially representative or ethically proportionate. As responsible learning practices are introduced, Avoidable Experimentation Risk declines to 53, indicating a transition from conventional lean experimentation toward validated learning that increasingly recognizes inclusion and public value as essential components of experiment quality. Under the strongest responsible experimentation conditions, Stakeholder Inclusion reaches 88, Ethical Safeguard Integration reaches 92, Resource Efficiency reaches 91, and Mission Continuity reaches 90, while Avoidable Experimentation Risk declines further to 30. These results suggest that startups do not necessarily need to sacrifice experimentation speed or resource efficiency in order to strengthen ethical and social safeguards. Instead, the simulation demonstrates that systematic stakeholder inclusion, proportionate ethical review, responsible resource allocation, and sustained mission alignment can improve the quality of entrepreneurial experimentation while simultaneously reducing avoidable risks. Overall, the findings reject the assumption that rigorous public-interest safeguards and efficient startup learning must exist in opposition, suggesting that both can be integrated within a responsible experimentation framework.

Table 2: Simulated Outcomes Across Lean Experimentation Maturity Levels

Lean Experimentation Maturity	Validated-Learning Efficiency	Public-Value Alignment	Stakeholder Inclusion	Ethical Safeguard Integration	Resource Efficiency	Mission Continuity	Avoidable Risk
20%	48	43	45	41	52	50	76
40%	59	56	57	54	63	61	65
60%	70	68	69	67	74	72	53
80%	82	81	80	81	84	83	41
100%	90	89	88	92	91	90	30

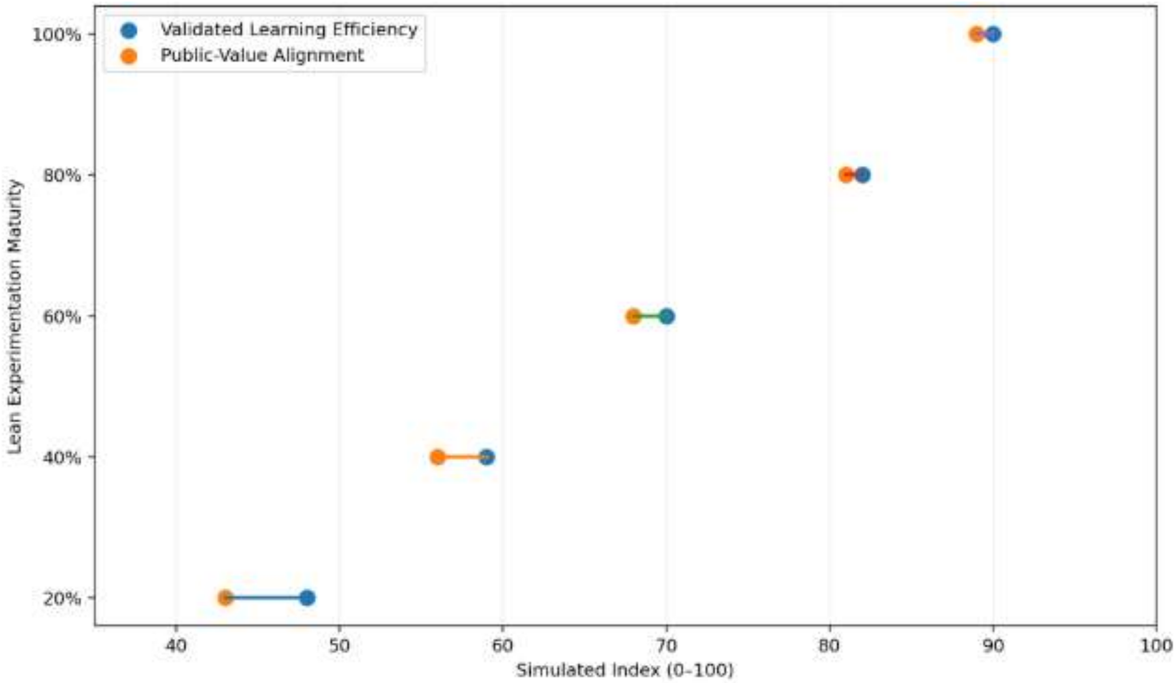
Note: All values are synthetic 0–100 indices developed exclusively for methodological illustration. They do not represent actual startups, users, citizens, or experimental participants.

American Journal of Advanced Multidisciplinary Innovation and Research (AJAMIR)
E-ISSN: XXXX-XXXX ● Website: www.ajamir.com ● Email: editor@ajamir.com

5.2 Learning Efficiency and Public-Value Alignment

Graph 1 uses a dumbbell format to compare two core dimensions of the proposed model at each maturity level: Validated-Learning Efficiency and Public-Value Alignment. At low maturity, the two indices remain separated, with entrepreneurial learning performing slightly better than public-value alignment. The difference narrows as experimentation governance becomes more mature.

Graph 1: Simulated Learning Efficiency and Public-Value Alignment Across Lean Experimentation Maturity



At the 20% condition, Learning Efficiency is 48 while Public-Value Alignment is 43, producing a five-point gap. At 100% maturity, the values reach 90 and 89 respectively, reducing the difference to only one point. The model therefore illustrates an important proposition: lean learning and public value become increasingly compatible when public-interest considerations are incorporated into hypotheses and experiment design instead of being evaluated only after a product has already been developed.

The finding is conceptually consistent with the scientific approach advocated by Camuffo and colleagues because clearer theories and tests should improve the entrepreneur's ability to specify exactly what evidence a test is intended to produce. Responsible-innovation principles add that the hypothesis set should include societal consequences and stakeholder concerns rather than only commercial assumptions.

5.3 Minimum Viability, Reversibility, and Experiment Risk

The reduction in Avoidable Experimentation Risk from 76 to 30 illustrates why a public-interest minimum viable product should be interpreted differently from an unrestricted “release early” philosophy. Minimum viability concerns the smallest configuration capable of testing a critical assumption. It does not justify omitting safeguards necessary to prevent foreseeable harm. An experiment involving sensitive user information, for example, may require appropriate privacy controls even if the technical prototype itself is rudimentary.

Reversibility becomes particularly important. Experiments are easier to justify when their negative consequences can be contained or reversed. A small interface test with informed volunteers differs fundamentally from deploying an unvalidated eligibility tool into a high-stakes public process. Lean methodology therefore requires an additional public-interest question: How reversible is the experiment if the underlying assumption proves wrong?

Public-interest startups can use this principle to sequence learning. Low-risk assumptions may be tested quickly through prototypes, simulations, mock services, interviews, usability sessions, or sandbox environments. Higher-risk assumptions may require stronger governance, independent review, or staged deployment. Lean experimentation remains rapid where rapidity is appropriate while becoming more deliberate where the social consequences of error are greater.

6. Discussion

6.1 From Minimum Viable Product to Minimum Responsible Experiment

The findings support replacing an overly narrow interpretation of the Minimum Viable Product with the broader idea of a Minimum Responsible Experiment for public-interest applications. The essential lean principle remains intact: entrepreneurs should test important assumptions before committing excessive resources. Blank's lean startup framework and the subsequent management literature emphasize iterative learning rather than treating the original business plan as fixed. The modification concerns the boundaries within which an experiment is considered valid.

A Minimum Responsible Experiment contains only the functionality necessary to produce decision-relevant evidence, but it also contains the safeguards proportionate to the expected consequences of the test. If accessibility is central to the claimed public benefit, accessibility cannot automatically be deferred until a later release. If a prototype collects sensitive personal data, reasonable data protection cannot be postponed because the product remains "experimental." If a system influences public participation, the startup must consider whether its test population excludes groups central to the intended public purpose.

This interpretation also improves entrepreneurial learning. An MVP tested among the wrong population may generate fast but misleading evidence. Similarly, a prototype whose usage depends upon hidden privacy compromises may appear commercially viable while concealing a future adoption or legitimacy problem. Responsible experimentation therefore improves evidence quality because it broadens the set of assumptions being validated.

6.2 Stakeholder Inclusion as an Experimental Capability

The second implication concerns the role of stakeholder participation. Civic-tech research demonstrates that technology can contribute to collaborative governance and public deliberation, but these benefits depend upon institutional relationships and meaningful participation rather than technological functionality alone. Public-interest startup teams therefore need the capability to identify who is affected by an innovation, who possesses relevant contextual knowledge, and who may be systematically missing from ordinary customer-discovery channels.

Stakeholder inclusion should nevertheless remain compatible with lean principles. The framework does not require every experiment to involve every possible constituency. Instead, experiment scope should determine participation requirements. Early problem discovery may involve interviews with several differently situated groups. Prototype usability may require targeted users with relevant accessibility characteristics. A later operational pilot may require public-sector partners, community organizations, frontline professionals, or independent experts.

The quality of inclusion also matters more than participant count. Token consultation performed after important decisions have already been made creates limited learning. Responsible lean experimentation instead incorporates stakeholder knowledge while hypotheses remain genuinely revisable. This aligns inclusion with the core entrepreneurial purpose of experimentation: discovering when the team's assumptions are wrong before those assumptions become expensive or institutionally entrenched.

6.3 Pivoting Without Losing the Public-Interest Mission

Lean startups are encouraged to revise products and business models when evidence contradicts core assumptions. Such pivoting is valuable because persistence with an invalid model can consume resources without improving impact. Yet public-interest startups face a distinctive risk: repeated adaptation to the easiest customers, highest-paying buyers, or most measurable outcomes can gradually move the venture away from its original social purpose.

The simulated increase in Mission Continuity from 50 to 90 therefore represents a governance mechanism rather than resistance to change. The startup should be able to pivot its technology, customer channel, implementation method, pricing logic, partnership structure, or revenue model while periodically evaluating whether the revised model still serves the public-interest objective that justified the venture. Public value should function as a strategic constraint on pivot direction, not as an excuse to resist evidence.

This approach is also consistent with public-value research showing that digital technology can create multiple kinds of societal value rather than a single efficiency outcome. A public-interest startup may discover that its original technical product is ineffective while the underlying public problem remains important. A responsible pivot can therefore abandon the product while preserving the mission. Conversely, a commercially successful pivot that removes the populations or public outcomes central to the original purpose should be recognized as a substantive mission change rather than described automatically as successful validated learning.

7. Conclusion

Lean experimentation provides a powerful approach for entrepreneurial environments in which uncertainty is high and premature commitment is costly. Public-interest technology startups can benefit substantially from explicit hypotheses, small tests, rapid feedback, iterative learning, and disciplined decisions about whether to persevere, modify, or abandon an approach. The entrepreneurship literature provides meaningful support for experimentation-based decision making, including evidence from randomized research showing the benefits of a more scientific entrepreneurial approach.

The present study argues, however, that public-interest contexts require a broader definition of experimental validity. A startup creating technology with consequences for citizens, patients, students, public-service users, vulnerable communities, or collective institutions should not validate a solution exclusively through adoption, engagement, revenue, or willingness to pay. Public value, accessibility, fairness, privacy, stakeholder inclusion, and foreseeable harm may form part of the startup's core assumptions and therefore belong inside the learning cycle rather than outside it.

The simulation illustrates this integrated model. Validated-Learning Efficiency rises from 48 to 90 as Lean Experimentation Maturity increases, while Public-Value Alignment rises from 43 to 89, Ethical Safeguard Integration reaches 92, Mission Continuity reaches 90, and Avoidable Experimentation Risk falls from 76 to 30. These values are synthetic and should not be interpreted as measured causal effects. Their purpose is to demonstrate how public responsibility and lean learning can be represented within the same analytical framework.

Future empirical research should examine real public-interest technology startups longitudinally and analyze individual experiment cycles rather than relying only on final venture outcomes. Researchers could investigate whether experiments containing explicit public-value and ethics hypotheses generate different pivot decisions, whether inclusive testing improves adoption among underserved populations, and whether safeguard integration slows development or instead prevents costly later redesign. Such evidence could establish whether responsible validated learning provides a more durable entrepreneurial model for technologies designed not merely to attract users, but to create defensible public value.

References

1. Ries, E. (2011). *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*. Crown Business.
2. Blank, S. (2013). Why the lean start-up changes everything. *Harvard Business Review, 91*(5), 63–72.
3. Ghezzi, A. (2019). Digital startups and the adoption and implementation of Lean Startup Approaches: Effectuation, bricolage and opportunity creation in practice. *Technological Forecasting and Social Change, 146*, 945–960. https://doi.org/10.1016/j.techfore.2018.09.017.
4. Ghezzi, A., & Cavallo, A. (2020). Agile business model innovation in digital entrepreneurship: Lean Startup Approaches. *Journal of Business Research, 110*, 519–537. https://doi.org/10.1016/j.jbusres.2018.06.013.
5. Shepherd, D. A., & Gruber, M. (2021). The Lean Startup Framework: Closing the academic–practitioner divide. *Entrepreneurship Theory and Practice, 45*(5), 967–998. https://doi.org/10.1177/1042258719899415.
6. Ghezzi, A. (2020). How entrepreneurs make sense of Lean Startup Approaches: Business models as cognitive lenses to generate fast and frugal heuristics. *Technological Forecasting and Social Change, 161*, 120324. https://doi.org/10.1016/j.techfore.2020.120324.
7. Wang, C., Wang, H., Dai, M., & Fang, Y. (2022). Lean Startup Approaches (LSAs): Convergence, integration and improvement. *Technological Forecasting and Social Change, 179*, 121640. https://doi.org/10.1016/j.techfore.2022.121640.

8. Wang, C., Dai, M., Fang, Y., & Liu, C. (2022). Ideas and methods of lean and agile startup in the VUCA era. *International Entrepreneurship and Management Journal, 18*(4), 1527–1544. https://doi.org/10.1007/s11365-022-00797-3.
9. Contigiani, A., & Levinthal, D. A. (2022). Experimentation, planning, and structure in early-stage ventures: Evidence from pitch decks. *Strategic Entrepreneurship Journal*. https://doi.org/10.1002/sej.1416.
10. Lortie, J., Cox, K. C., Kelly, S., & Bolivar, T. (2022). Two-factor learning for launch: How entrepreneurs can increase the probability of positive responses to their minimum viable products. *Journal of Entrepreneurship and Innovation in Emerging Economies, 8*(4). https://doi.org/10.1177/2515127421994788.
11. Bocken, N., & Snihur, Y. (2020). Lean Startup and the business model: Experimenting for novelty and impact. *Long Range Planning, 53*(4), 101953. https://doi.org/10.1016/j.lrp.2019.101953.
12. Scheuenstuhl, F., Bican, P. M., & Brem, A. (2021). How can the Lean Startup approach improve the innovation process of established companies? An experimental approach. *International Journal of Innovation Management*, *25*(7). https://doi.org/10.1142/S1363919621500298.
13. Wang, C., Dai, M., Fang, Y., & Liu, C. (2022). An exploration of the applicability of Lean Startup in small non-digital firms: An effectuation perspective. *International Journal of Entrepreneurial Behavior & Research*, *28*(9), 198–218. https://doi.org/10.1108/IJEBR-04-2021-0270.
14. Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, *42*(9), 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008.
15. Owen, R., Stilgoe, J., Macnaghten, P., Gorman, M., Fisher, E., & Guston, D. (2013). A framework for responsible innovation. In R. Owen, J. Bessant, & M. Heintz (Eds.), *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society* (pp. 27–50). Wiley.
16. von Schomberg, R. (2013). A vision of responsible research and innovation. In R. Owen, J. Bessant, & M. Heintz (Eds.), *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society* (pp. 51–74). Wiley.
17. Owen, R., Bessant, J., & Heintz, M. (Eds.). (2013). *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*. Wiley.
18. Ko, E., & Kim, Y. (2020). Why do firms implement responsible innovation? The case of emerging technologies in South Korea. *Science and Engineering Ethics*, *26*, 2663–2692.
19. Rödl, M. B., Boons, F., & Spekkink, W. (2022). From responsible to responsive innovation: A systemic and historically sensitive approach to innovation processes. *Technological Forecasting and Social Change*, *174*, 121231. https://doi.org/10.1016/j.techfore.2021.121231.
20. Ulnicane, I., Mahfoud, T., & Salles, A. (2022). Experimentation, learning, and dialogue: An RRI-inspired approach to dual-use of concern. *Journal of Responsible Innovation, 10*(1), 1–18. https://doi.org/10.1080/23299460.2022.2094071