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HoST - Journal of History of Science and Technology  
Vol. 19, no. 2, December 2025, pp. 42-64  
10.2478/host-2025-0013

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THEMATIC DOSSIER  
SMALL SCIENCE: PERSPECTIVES ON CONTEMPORARY SMALL-SCALE RESEARCH

# *Jugaad* as Small Science: The ‘e-Rickshaw’ Conundrum in Delhi

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**Abstract:** The emerging discourse on “small science” and “slow science” broadens the scope of the STS scholarship by problematizing the question of scale in doing science. It claims that small science is not only about doing things at a small scale, but also about doing different things. The scholarship shares space with the emerging frugal innovation scholarship, which advocates for humane technologies with a greater degree of simplicity, decentralised control, greater customisation possibilities, and participation of “laypeople” in the making of these technologies. However, these innovations are, at times, criticised for not being based on (idealised) “science.” We draw upon philosophical, and historical studies on scientific methods to relook at the claim of absent science in *jugaad*. We take a scaled up *jugaad* transportation technology developed by laypeople in the informal economy in the city of Delhi for the analysis. We find that *jugaad* is an outcome of a carefully designed search process, aided by alertness of mind, knowledge about immediate material and knowledge environment, and a preference for accessibility and affordability in creating new technologies. It involves reuse, repurposing, and improvisation. The paper raises broad questions about how *jugaad* operates, achieves legitimacy, and survives public scrutiny, to create a space for, a more human-centred, “*jugaad-science*”.

**Keywords:** *Jugaad*; small science; informal transportation; paratransit; Delhi

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## Introduction

“Soleckshaw solar powered rickshaws provide a breath of fresh air.” With this headline, *The Times* in 2008 celebrated *Soleckshaw* as a boon for the manually driven cycle rickshaw pullers of the Indian city of Delhi.<sup>1</sup> *Soleckshaw* was a battery-assisted, solar-powered paratransit vehicle, developed by the Indian state-funded premier research institution CMERI-CSIR.<sup>2</sup> This vehicle upgraded the existing manual cycle rickshaws to a motor-assisted one, to reduce drudgery in an environment-friendly manner in the capital city of India.<sup>3</sup> Despite the strong scientific and technological backing, however, the *Soleckshaw* failed.<sup>4</sup> Nevertheless, the Indian paratransit space quietly underwent a transformative shift with the emergence of e-Rickshaw—an electric paratransit vehicle evolved in a bottom-up manner, without any support from the mainstream institutions of science and technology. It was adapted and manufactured in small and obscure sites, scattered across the city of Delhi. Colloquially, a ‘*jugaad*’, eventually triumphed over the product of the organised and protocolized science. The e-rickshaw has, since then, transformed the Indian paratransit space and is used by 60 million+ passengers every day.<sup>5</sup>

The innovation potential of *jugaad* has, of late, been recognised by innovation scholars, and forms the core of a variety of discourses in innovation studies today, namely, grassroots innovation, informal sector innovation and frugal innovation.<sup>6</sup> These studies highlight how such context-specific innovations promote inclusiveness and justice and foster democratic control over technology. Their inadequate scale, however, often remains a sore point, and it is often alleged, implicitly or explicitly, that they remain ‘local’ and ‘second-rate’

<sup>1</sup> Jerney Page, “Soleckshaw Solar Powered Rickshaws Provide a Breath of Fresh Air,” *The Times*, October 18, 2008.

<sup>2</sup> Council of Scientific & Industrial Research (CSIR) - Central Mechanical Engineering Research Institute (CMERI).

<sup>3</sup> Nisha Chandran and Samir Kumar Brahmachari, “Technology, Knowledge and Markets: Connecting the Dots—Electric Rickshaw in India as a Case Study,” *Journal of Frugal Innovation* 1, no. 3 (2015).

<sup>4</sup> IDFC, “Organising Intermediate Public Transport for an Urbanising India,” I, 2012. On the history of failed technologies, see, for instance, Bruno Latour, *Aramis or the Love of Technology* (Cambridge: Harvard University Press, 1996).

<sup>5</sup> *Jugaad* is a colloquial term used in a variety of contexts. In this paper, we use it in the limited context of technological and scientific activities in informal spaces. Ashish K. Mishra and Shally Seth Mohile, “The Controversial E-Rickshaw Takes off amid Safety Concerns,” *Mint*, October 15, 2014; Vinu Goel and Karan Deep Singh, “Inside India’s Messy Electric Vehicle Revolution,” *The New York Times*, August 22, 2019.

<sup>6</sup> Hemant Kumar and Gautam Sharma, *Grassroots Innovation: Discourse, Policy and Practice in the Global South* (Abingdon: Routledge, 2024); Mammo Muchi *et al.*, *Informal Sector Innovations: Insights from the Global South* (Abingdon: Routledge, 2017); André Leliveld *et al.*, eds., *Handbook on Frugal Innovation* (Cheltenham: Edward Elgar Publishing, 2023).

because the processes do not comply with those supported by mainstream science and technology.<sup>7</sup> Systematic, structured, repeatable processes and an emphasis on conforming to the protocols of modern science and technology seem to be at the core of providing legitimacy to mainstream innovations.<sup>8</sup> The failure of *Soleckshaw* at the hands of the *jugaad* e-rickshaw presents a counterexample worth investigating in this context.

The success of the *jugaad* e-rickshaw is important from an innovation policy perspective, too. Despite a growing body of literature, funding and policy support for *jugaad* and informal sector innovation remain below par.<sup>9</sup> India did witness a certain degree of policy enthusiasm in this regard in the last couple of decades, where funding, creating intellectual property rights mechanisms and facilitating commercialisation of such innovations were encouraged. Even that limited enthusiasm seems to have dried up in recent years. For instance, the “Atal Innovation Mission” keeps *jugaad* in the informal economy at arm’s length, even though promoting tinkering and community innovation remains one of its cherished policy goal. For India’s techno-scientific elites, *jugaad* remains untouchable, allegedly promoting “quick-fix,” “corruption,” and hindering “systematic innovation.” *Jugaad*, in this narrative, represents activities that are the extreme opposite of what ideal, organised science stands for.<sup>10</sup>

The underlying assumption is a perceived difference between the ‘ideal’ methods of science and the way *jugaad* technologies are made. Science, in this narrative, refers to a set of universally applicable processes and repeatable protocols. *Jugaad*, on the other hand, occupies the other extreme of the continuum, reflecting mere idiosyncrasies and “ad-hocism.” These idealised features of science seek to insulate science from actionable knowledge that does not connect to, or follow, scientific theories.<sup>11</sup>

<sup>7</sup> Balkrishna C. Rao, “The Science Underlying Frugal Innovations Should Not Be Frugal,” *Royal Society Open Science* 6 (2019): 180421. See also Greetje Schouten and Peter Knorringa, “Frugal Innovation and Legitimacy,” in Leliveld et al, *Handbook on Frugal Innovation*, 142–53.

<sup>8</sup> Raluca Bunduchi *et al.*, “Legitimacy and Innovation in Social Enterprises,” *International Small Business Journal* 41, no. 4 (2023): 371–400; Schouten and Knorringa, “Frugal Innovation and Legitimacy.”

<sup>9</sup> Rajbeer Singh, Shilpa Mishra, and Krishna Tripathi, “Analysing Acceptability of E-Rickshaw as a Public Transport Innovation in Delhi: A Responsible Innovation Perspective,” *Technological Forecasting and Social Change* 170, May (2021): 120908; Dwarkeshwar Dutt, “How Power and Politics Shape Niche-Regime Interactions: A View from the Global South,” *Environmental Innovation and Societal Transitions* 43 (2022): 320–30; Simon Harding and Milind Kandlikar, “Explaining the Rapid Emergence of Battery-Rickshaws in New Delhi: Supply-Demand, Regulation and Political Mobilisation,” *World Development Perspectives* 7–8, March (2017): 22–27.

<sup>10</sup> D. C. Sharma, *Indian Innovation, Not Jugaad-100 Ideas That Transformed India* (New Delhi: Roli Books Private, 2022); Rao, “The Science Underlying Frugal Innovations Should Not Be Frugal.” In Europe too, allegedly, “no one seems to lobby for such innovations” (personal conversation with officials at the European Commission, Brussels, 12 February 2020).

<sup>11</sup> Edwin T. Layton Jr, “Technology as Knowledge,” *Technology and Culture* 15, no. 1 (1974): 31–41.

The evolving scholarship on “small science,” “citizen science” and “slow science,” in the STS tradition, offers a new entry point into this debate by blurring such ‘artificial’ boundaries. It underscores that the goals, directions, and processes of scientific research may be prejudiced, reflective, unorganised, experience-driven, diverse and context-specific. It highlights how the socio-political nature of science makes scientific processes deviate from their supposed idealised rational path. The idealistic nature of science is claustrophobic and exclusionary, too, making science market-conscious and capital-intensive, excluding the common people from the realm of its production and use.<sup>12</sup>

However, the evidence for “small science” or “slow science” comes overwhelmingly either from historical settings or involves people who are formally trained in science. How science operates in the informal spaces, by people not formally trained in science, or by people who lack theoretical understanding for their technological work, can, therefore, broaden the ambit of this literature.<sup>13</sup> Transgressing such boundaries would help establish a dialogue with the marginalised “missing people” whose knowledge and actions remain under-recognised, or unaccounted for, in official cartographies or genealogies.<sup>14</sup> Such spaces, in fact, represent around 2 billion people working in the informal economies, and around 40% of the gross domestic products of some of the most populous countries of the world.

Juxtaposing against the scholarship on the methods of science, we analyse the process, goals, drivers, and actors in *jugaad*. We aim to understand the way it interacts with the formal (big) science and negotiates the regulatory space. An understanding of these aspects would extend the scope of the scholarship on small science by opening it up to a wide, complex set of contemporary themes observed in the vast informal economy of many countries. We deliberate upon the agenda of *jugaad*. We then discuss historical, contemporary and empirical evidence from the informal/popular transportation space to analyse how *jugaad* methods unfold in the technology space and negotiate with the regulatory structure. This discussion is followed by the discussion of our data and the case study. We finally analyse how *jugaad* recalibrates the scope and contour of small science using the case of the

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<sup>12</sup> Thomas Nickles, “Historicist Theories of Scientific Rationality,” *The Stanford Encyclopedia of Philosophy* (Spring 2021 Edition), Edward N. Zalta, ed. <https://plato.stanford.edu/archives/spr2021/entries/rationality-historicist/>; J. H. Capshew and K. A. Rader, “Big Science: Price to the Present,” *Osiris* 7, no. 1 (1992): 3–25; Sanjay Jain, “From Jugaad to Jugalbandi: Understanding the Changing Nature of Indian Innovation,” *Asia Pacific Journal of Management* 39, no. 1 (2022): 1–26.

<sup>13</sup> These issues have strong overlaps with the discussions on amateur science, indigenous science, or subaltern science.

<sup>14</sup> Hemant Kumar and Saradindu Bhaduri, “Jugaad to Grassroot Innovations: Understanding the Landscape of the Informal Sector Innovations in India,” *African Journal of Science, Technology, Innovation and Development* 6, no. 1 (2014): 13–22; Rosi Braidotti, *Posthuman Knowledge* (Cambridge: Polity, 2019); Rosi Braidotti, “A Theoretical Framework for the Critical Posthumanities,” *Theory, Culture & Society* 36, no. 6 (2019): 31–61.

e-rickshaw. We primarily use policy briefs, government reports, news reports, parliamentary debates, and official statements. A limited amount of primary data has also been analysed to understand the way the manufacturing and organisational mechanisms of such vehicles have evolved in and around Delhi.

## Setting the Contours of *Jugaad*

In popular technocratic perception, *jugaad* mostly has a negative connotation, and public discussion is guided by what it is deficient in, i.e. a lack of structure, systemic thinking, and safety and quality foresight.<sup>15</sup>

Scholars have discussed the relevance of *jugaad* methods for small and marginal knowledge systems.<sup>16</sup> “People are encouraged to use some *jugaad* when faced with a blank wall or a difficult problem.” *Jugaad* is creative improvisation, a tool to somehow find a solution, ingenuity, a refusal to accept defeat, initiative, quick thinking, cunning, resolve and all of the above.<sup>17</sup> For Heeks, *jugaad* closes the “design-reality gaps” that other innovations create; it grows in the gaps left out by the protocolized solutions.<sup>18</sup> *Jugaad* involves reuse, repurposing, and improvisation.<sup>19</sup> *Jugaad* is about alertness of mind, knowledge about existing possibilities available in the immediate environment.<sup>20</sup>

Within the innovation scholarship, *jugaad* shares traits with frugality, which deeply appreciates the trial-error method of exploration, where emphasis is given on “heuristics” over “well-designed rules” or on performance in real real-world environment more than their logical validity.<sup>21</sup> *Jugaad* connects to frugality, which, by emphasising prudence, reasonableness, and

<sup>15</sup> Thomas Birtchnell, “Jugaad as Systemic Risk and Disruptive Innovation in India,” *Contemporary South Asia* 19, no. 4 (December 2011): 357–372.

<sup>16</sup> Dean A. Shepherd, Vinit Parida, and Joakim Wincent, “The Surprising Duality of *Jugaad*: Low Firm Growth and High Inclusive Growth,” *Journal of Management Studies* 57, no. 1 (2020): 87–128; Kumar and Bhaduri, “Jugaad to Grassroot Innovations.”

<sup>17</sup> Pavan K. Varma, *Being Indian: The Truth about Why the Twenty-First Century Will Be India's* (New Delhi: Penguin Group India, 2005), in Chapter 3, epub version.

<sup>18</sup> Richard Heeks, “Where Next for ICTs and International Development ?” in OECD, ed. *ICTS For Development: Improving Policy Coherence* (Paris: OECD Publishing, 2009), 29–72, on p. 51.

<sup>19</sup> Jain, “From Jugaad to Jugalbandi;” Simon Werrett, *Thrifty Science. Making the Most of Materials in the History of Experiment* (Chicago: Chicago University Press, 2019).

<sup>20</sup> Kumar and Bhaduri, “Jugaad to Grassroot Innovations,” p. 3.

<sup>21</sup> Saradindu Bhaduri, Ariane Agnes Corradi, Hemant Kumar, and Fayaz Ahmad Sheikh, “Frugality in Innovation Processes: A Heuristics-based Perspective From the Informal Economy,” in Leliveld et al, *Handbook on Frugal Innovation*, 69–82.

justice, opens avenues for a more “human-centred” discourse in science, technology and innovation.<sup>22</sup>

In *Against Method*, Paul Feyerabend makes a pioneering attempt to emphasise that the progress of science does not depend on *exceptionless* methodological rules. Science has an evolutionary nature which is shaped by the physical and historical conditions. The over-reliance on rigid methods not only impacts science itself, but it also impacts humanity at large. Science needs to be adaptive, flexible, and open and free from political control—“All methodologies have their limitations, and the only ‘rule’ that survives is ‘anything goes’.” By “anything goes,” he focuses on the all-pervasive nature of knowledge acquisition processes, instead of relying on a set of fixed and universal rules.

(T)he events, procedures and results that constitute the sciences have no common structure; there are no elements that occur in every scientific investigation but are missing elsewhere... Successful research does not obey general standards; it relies on now on one trick now on another . . .<sup>23</sup>

Scientific success has no simple rule: “all we can do is to give a historical account of the details, including social circumstances, accidents, and *personal idiosyncrasies*.”<sup>24</sup> Repeatability and universality of scientific methods, if at all, are an outcome of an elaborate and long-drawn social, political and economic process, and not intrinsic to science.<sup>25</sup>

Braidotti brings in the aspect of “missing people”- “real-life subjects whose knowledge never made it into any of the official cartographies or genealogies.”<sup>26</sup> She adopts Deleuze and Guattari’s idea of “royal science” to distinguish between major science and minor science.<sup>27</sup> While major science is “sedentary and protocol-bound” and “follows an axiomatic model of scientific experimentation that follows universal theorems and set rules,” minor science has a relational and open approach, “more autonomous, radical and potentially subversive, and developed through an expansion of less official and often non-institutionalised practices and discourses.” Minor science “is situated, perspectivist and able to combine critique with the

<sup>22</sup> Shekhar Jain and Saradindu Bhaduri, “The Many Facets of Frugality: Insights from a Quasi-Comprehensive Literature Survey,” *Journal of Scientometric Research* 10, no. 2 (2021): 265–78; Saradindu Bhaduri *et al.*, “Frugality in Innovation Processes.”

<sup>23</sup> Paul Feyerabend, *Against Method: Outline of an Anarchistic Theory of Knowledge* (Verso Books, 2020 [1975]), p. xix.

<sup>24</sup> *Ibid.*

<sup>25</sup> David N. Livingstone, *Putting Science in its Place* (Chicago: University of Chicago Press, 2003).

<sup>26</sup> Braidotti, *Posthuman Knowledge*, chapter 4.

<sup>27</sup> Gilles Deleuze, Felix Guattari, and Brian Massumi, *Nomadology: The War Machine* (New York: Semiotext(e), 1986).

creation of new concepts. It is “underfunded and marginalised, but ethically transformative and politically empowering.”<sup>28</sup>

In this discussion on methods and marginalisation of science, the idea of “technological science” is an important addition. This aspect of science emerged when many technology historians looked at science selectively from the perspective of practice.<sup>29</sup> Hansson pushes this argument and emphasises that “technological sciences are neither branches nor applications of the natural sciences, but form a different group of sciences with specific characteristics of their own.”<sup>30</sup>

### ***Jugaad* in Transportation: Prevalent Narratives**

*Jugaad* is conventionally used in India for vehicles manufactured or modified in the informal economy to suit local needs. There are numerous examples where public mobility benefits from such informal transportation, often referred to as popular transportation (Figure 1). Scholars have identified that these vehicles sustain and survive through a complex relationship with global manufacturers as well as the local network of traders, drivers, and mechanics.<sup>31</sup>

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<sup>28</sup> Braidotti, *Posthuman Knowledge*, chapter 5.

<sup>29</sup> In *What Is This Thing Called Science?*, Chalmers criticises this trend. He argues: “The kind of history of science involved is a selective kind of history, and certainly not the only kind of history of science that is possible or important.” Alan F. Chalmers, *What Is This Thing Called Science?* 3rd ed. (Indianapolis: Hackett Publishing, 1999), 248.

<sup>30</sup> Sven Ove Hansson, “What is Technological Science?,” *Studies in History and Philosophy of Science Part A* 38, no. 3 (2007): 523–27, p. 523.

<sup>31</sup> N.a., “We’re Calling It Popular Transportation (Full)” accessed January 15, 2025, <https://www.populartransport.net/popular-transportation>. Yann Philippe Tastevin, “The Indian Auto Rickshaw in Egypt: An Ethnography of Transnational Trade Connections,” *Articulo. Journal of Urban Research* 12 (2015) <https://doi.org/10.4000/articulo.2872>.



Figure 1—Different types of informal transportation from different countries. a) Phat-Patias from New Delhi, India;<sup>32</sup> b) ‘Pragyia’ Taxi-Tricycles in Ghana;<sup>33</sup> c) Informal Autorickshaw in Egypt;<sup>34</sup> d) ‘Salonis’ Taxi-Tricycles in the Ivory Coast.<sup>35</sup>

The people within the ecosystem of informal transportation often localise the vehicular technology in ways that vehicles are kept running for extended periods of time, which appears technically impossible to many.<sup>36</sup> They cultivate their own sense, in their own terms, of technological science behind these machines, often using reverse engineering, trial and error, local experimentation, and improvised use of spare parts and tools. Their sensory and experiential knowledge helps them adapt or manipulate the technology, develop repair ecosystems, and keep the machine usable, delaying technological obsolescence. In Ghana, for instance, people rarely plan to replace a vehicle. Rather, vehicles are periodically repaired

<sup>32</sup> “123637.Jpg (500×571),” accessed April 7, 2025, <https://www.team-bhp.com/forum/iipcache/123637.jpg>.

<sup>33</sup> “Pragyia Has Come to Stay” accessed April 7, 2025, <https://www.ghanabusinessnews.com/2021/10/31/pragyia-has-come-to-stay-mintah-nyarku/>.

<sup>34</sup> Tastevin, “The Indian Auto Rickshaw in Egypt.”

<sup>35</sup> “Saloni....” accessed April 7, 2025, <https://web.archive.org/web/20240520145108/https://cyriacgbogou.ci/2019/02/saloni-debarque-a-jacqueville/>.

<sup>36</sup> Jojada Verrips and Birgit Meyer, “Kwaku’s Car: The Struggles and Stories of a Ghanaian Long-Distance Taxi-Driver,” in *Car Cultures*, D. Miller, ed. (London: Routledge, 2001), 153–84.

in areas called “magazines,” which are places “for making things of all sorts” using simple tools. Edgerton notes that “the vehicle is reworked in the local system, it reaches a state of apparent equilibrium in which it seems to be maintained indefinitely... it is a condition of maintenance by constant repair.”<sup>37</sup> This challenge to the hegemony of planned obsolescence is, presumably, an attempt to subvert the capitalist control of technological science.<sup>38</sup>

Verrips and Meyer call this “a tremendously powerful will and capacity... of ordinary people – to keep the engine working by all means.” People engaged in the repair business develop an intimate relationship with technology, through sensory experiences of taste, hearing and smell to understand the technological glitches in their vehicles. Scientific knowledge is internalised using the human sensory organs, not necessarily backed by theoretical knowledge. The Ghana mechanics “tropicalise” or “baptise” the imported cars to make them functional in their climate. Such tropicalization includes, for instance, replacing the radiator with a propeller to keep the car cool; or raising “the oil level in... shock-absorbers beyond normal” so that one could “drive more comfortably on roads full of potholes.”<sup>39</sup> The need for “baptisation” reflects the rigidities and insufficiencies of the mainstream automobile science to keep a car functional in such regions.

Another embodiment of *jugaad* methods within transportation space is reflected in the evolution of unorganised/informal three-wheeler autorickshaws in Cairo, Egypt (Figure 1c). Tastevin highlights that an Indian cloth trader—*Nayan*—becomes an exporter of generic or unbranded auto parts through his *hustles*, which eventually shaped the evolution of these autorickshaws. Using these parts, the repair economy in Cairo evolved to eventually outcompete the reputed transnational players.<sup>40</sup> Similar is the case of “Salonis” Taxi-Tricycles in the Ivory Coast. These taxis evolved in response to persisting marginalities—spatial, infrastructural, socio-economic, legal, and regulatory—in the city of Abidjan, Ivory Coast. These vehicles maintain a strong transnational linkage for imports of auto parts by local traders, drivers, mechanics and others.<sup>41</sup>

<sup>37</sup> David Edgerton, *The Shock of the Old. Technology and Global History since 1900* (London: Profile Books, 2006), p. 84.

<sup>38</sup> F. J. Santos Arteaga and P. Frigato, “Planned Obsolescence and the Manufacturing of Doubt: On Social Costs and the Evolutionary Theory of the Firm,” in P. Ramazzotti, P. Frigato, and W. Elsner eds. *Social Costs Today: Institutional Analyses of the Present Crises* (London: Routledge, 2012): 73-95.

<sup>39</sup> Verrips and Meyer, “Kwaku’s Car,” 178.

<sup>40</sup> Tastevin, “The Indian Auto Rickshaw in Egypt;” Yann Philippe Tastevin, “Bajaj in Egypt or The Discreet Propagation of Autorickshaw in Africa,” *Autrepart* 76, no. 4 (2015): 127–46.

<sup>41</sup> Jacob Doherty and Vakaramoko Bamba and Irène Kassi-Djodjo, “Multiple Marginality and the Emergence of Popular Transport: ‘Saloni’ Taxi-Tricycles in Abidjan, Ivory Coast,” *Cybergeo*, 2021, doi:10.4000/cybergeo. 36017.

The *jugaad* in the Indian transportation sector has survived, sustained, and flourished even in the era of rapid “modernisation” of the automobile manufacturing landscape over the last few decades. In India, the growth and ubiquity of *jugaad* vehicles are often linked to its robust auto parts industry, and the ingenuity of the mechanics to fabricate auto parts.<sup>42</sup> Kumar and Sethi share an anecdote where, apparently, a Japanese automobile company had sent a team to India to understand the skills and facilities available for car repair/service, to gauge the possibility of starting a car manufacturing unit in India. The team found that “every repair and service organization, irrespective of size, ...notwithstanding shortages of parts, lack of proper service equipment, deficiencies in infrastructure, ...had no problem in repairing not only locally made cars but also the aging imported cars for which no spare parts were available.”<sup>43</sup> The local mechanics may not have the exact theoretical knowledge of “automobile science,” but they successfully adapted to supplement the vehicle industry.<sup>44</sup>

*Jugaad* in the Indian transportation history, however, is much older than this. It began with *Phat-Phatpatias* (Figure 1a), which were passenger vehicles, repurposed out of the British era Harley Davidson motorbikes. *Phat-Phatpatias* ran for around five decades and were serviced regularly, with locally made parts. Jodha notes that “there was little left of the original machinery in these Harley Davidson bikes—except the fuel tank, mudguards and the occasional engine casing” due to the “gradual replacement of engine parts with local ones over the years and finally even the engine.”<sup>45</sup>

*Chakda* (छकड़ा) is another example, still operational in the Gujarat state of India. This vehicle was designed in 1972 by *Jagjivan Chandra* of Gujarat and was later regularised by the Gujarat state government around 2003 as a passenger vehicle for rural areas. The *Chakda* has reportedly had a similar evolutionary path as that of *Phat-patias*. They were first made out of 3.5 HP BSA motorcycles, the Bullet. With time, *Chakda* saw more modifications, and its Bullet engine was replaced with a 7.5 HP diesel pump used for drawing water from wells or as an outboard motor for boats, while the gearbox and clutch were retained from the old design. Atul Autos, which pioneered in making *Chakda*, exported these vehicles to East African countries and Bangladesh.<sup>46</sup> On the other hand, the Punjabi version of the

<sup>42</sup> S. Mitra, “Grassroots Capitalism Thrives in India,” *Index of Economic Freedom*, 2006, 39–47; Brink Lindsey, “The Rule of Lawlessness,” in *Against The Dead Hand: The Uncertain Struggle for Global Capitalism* (New York: John Wiley & Sons, 2002), 162–88.

<sup>43</sup> Rajesh Kumar and Anand Kumar Sethi, “Understanding India,” in *Doing Business in India* (New York: Palgrave Macmillan, 2005): 73–83, on 76.

<sup>44</sup> Smriti Sawkar, “A Small Car for a Small Family: Building India’s First ‘People’s Car’,” *Contemporary South Asia* 30, no. 4 (October 2, 2022): 465–80.

<sup>45</sup> Vijay S. Jodha, “The Case of the Phat-Phatia,” *India International Centre Quarterly*, 30, no. 2 (2003): 41–42.

<sup>46</sup> Uday Mahurkar, “Rural Ingenuity Comes up with a Vehicle Best Suited for Dusty Saurashtra Region in Gujarat,” *India Today*, June 23, 2003.

*jugaad* vehicle i.e. *Maruta/Garukha*, were allowed for poorer sections and remote rural areas of Punjab in 1977 by then transport minister of Punjab, but were subsequently outlawed in 1994 by the Punjab and Haryana High court (although reports suggest that they never ceased to operate and were sold to various parts of the country). Even in 2008, the *Gharukha* were considered as an “asset” in a village household survey submitted to the Department of Planning, Government of Punjab, which indicates the relevance of such vehicles in rural settings even after they were outlawed.<sup>47</sup>

Many such vehicles continue to run on Indian roads. According to Anil Gupta, a pioneer in documenting such innovations, “there are thousands of them. Gujarat alone has about 30,000 varieties of vehicles, which are low-cost, innovative and with wide applications.”<sup>48</sup> A noteworthy aspect of the *jugaad* vehicles is that they have constantly evolved and adopted new technology. We now discuss the cases of e-rickshaw and *battery-jugaad* in detail.

S. No	Code	Stakeholder	Number of Visit/ Count
1	R1(I,M,A,P)	Innovator, Manufacturer, aggregator, Part Supplier	6
2	R2(I,M)	Manufacturer, Innovator	2
3	R3(I,M,A)	Manufacturer, Aggregator, Innovator	2
4	R4(M)	Manufacturer	2
5	R5(I,M,A,P,S)	Aggregator, Manufacturer, Part Supplier, Syndicate	3
6	R6(I,M,P,R)	Innovator, Manufacturer, Part Supplier, Repair	2
7	R7(I,M,R)	Innovator, Manufacturer, Repair	2
8	R8(M,A)	Manufacturer, Aggregator	3
9	R9(M,A,S)	Manufacturer, Aggregator	1

<sup>47</sup> Mohinder Singh, *Punjab 2000: Political and Socio-Economic Developments* (Anamika Publishers & Distributors, 2001); R.K. Sinha, “Tech Trick to Tweak Transport Laws - Jugaad Innovation Paves Way for Transporters to Dodge Motor Vehicles Act,” *Telegraph India*, December 1, 2011; Balvinder Singh *et al.*, Model Questionnaire, 2008.

<sup>48</sup> Saira Kurup, “Homemade Nano,” *The Times of India*, March 29, 2009.

S. No	Code	Stakeholder	Number of Visit/ Count
10	R10(M)	Manufacturer	1
11	R11(P)	Part Supplier	1
12	R12(R)	Repair Shop	2
13	R13(M,R, P)	Manufacturer, Repair, Parts	1
14	R14(S, M)	Spare part, Manufacturer	1

Source: own compilation.

Stakeholder	Number
Ghaziabad Municipality Officers	2
Delhi Police	2
Uttar Pradesh Police	3
Driver Battery-jugaad	25

Source: own compilation.

## Field Observations and Discussion

### *Evolution of Battery-driven Paratransit in Delhi*

The government of Delhi introduced *Soleckshaw* in the year 2010. As discussed, these vehicles were innovated by the CSIR, with motor power less than 0.25 kW, and positioned as an alternative to widespread manual rickshaw pulling by the regional government of Delhi. The ownership of the technology of these vehicles was with CSIR, and its manufacturing required a license. CSIR designed these vehicles as “Green Vehicles” with a solar panel for battery recharge. This motivated the people in the informal economy to develop their own versions of battery-run rickshaws, and the e-Rickshaw was introduced in Delhi, with imported parts from China.<sup>49</sup>

Initially, e-Rickshaws operated outside the ambit of the Indian Motor vehicle Act (MVA). The then rule no. 2(u) of the Central Motor Vehicles Rules (CMVR) specified that battery

<sup>49</sup> Chandran and Brahmachari, “Technology, Knowledge and Markets”; IDFC, Organising Intermediate Public Transport for an Urbanising India, *Quarterly Research Note*, no. 17, 2012.

operated vehicle shall not be considered motor vehicle, “if the thirty minutes power of the motor is less than 0.25 kW.; the maximum speed of the vehicle is less than 25 km/h.”<sup>50</sup> This helped e-Rickshaw to operate without certification(s) required for operating a “motor vehicle.” Over time, the e-Rickshaw gained a “legitimacy threshold” which helped them challenge the hostile government policies to the extent that the existing rules were bent to grant them a regulatory approval.<sup>51</sup>



Fig. 2 — *Soleckshaw*<sup>52</sup>;

<sup>50</sup> SHANAWAZ KHAN Vs MCD, “W.P. (C) 5764/2013 & CM No.10017/2014 SHANAWAZ,” Delhi High Court, September 9, 2014.

<sup>51</sup> The e-Rickshaw had a significant effect on the manual cycle rickshaw pulling and many of the cycle rickshaw ecosystem actors, including drivers and manufacturers, smoothly shifted to this new informal vehicle. Anupam Chakravartty, “Last Mile Chaos,” *Down To Earth*, April 30, 2014, <https://www.downtoearth.org.in/coverage/last-mile-chaos-44033>; Shashank Singh, *A Study of the Battery Operated E-Rickshaws in the State of Delhi*, 2014.

<sup>52</sup> “Soleckshaw” accessed January 15, 2025, <https://blog.mygov.in/soleckshaw-a-solar-electric->

Fig. 3 — b) e-Rickshaw<sup>53</sup>

The Government of Delhi was initially hostile towards these informally manufactured vehicles. They amended the rules to bring them under the Motor Vehicle Act to impose stringent regulations. In August 2014, following an accident involving an e-Rickshaw in which a child died, the court directed the government to restrict its movement until a suitable regulation was formed.<sup>54</sup> However, the legislative election in Delhi was to be held soon. The number of e-Rickshaws by then had swelled to around 100,000 with multiple designs and configurations.<sup>55</sup> This made e-Rickshaw an effective interest group large enough for political relevance for the forthcoming election in Delhi. This bargaining power made them successful in getting the Parliament to amend the Motor Vehicle Act of India to regularise the e-Rickshaw.<sup>56</sup>

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rickshaw-for-eco-friendly-urban-transport/.

<sup>53</sup> SHANAWAZ KHAN Vs MCD, “W.P. (C) 5764/2013 & CM No.10017/2014 SHANAWAZ.”; Salimah Shivji, “How India’s Electric Rickshaw Revolution Is Forging a Low-Carbon Future” November 7, 2022, <https://www.cbc.ca/news/world/india-electric-rickshaw-revolution-low-carbon-future-1.6642423>; last accessed on 3 December 2025.

<sup>54</sup> SHANAWAZ KHAN Vs MCD, “W.P. (C) 5764/2013 & CM No.10017/2014 SHANAWAZ.”

<sup>55</sup> Simon Harding, “The Battery Rickshaw ‘Crisis’ in New Delhi,” *Journal of Indian Law and Society* 6 (2014): 74–88.

<sup>56</sup> India follows a federal system of governance in which authority is constitutionally divided between the Union Government at the national level and the State Governments at the subnational level.

The government of India defined a new class of vehicle within the existing act. The requirement of a driver's educational qualification for obtaining a commercial driving license was removed for e-Rickshaws.<sup>57</sup> Additionally, the roles of aggregators were discouraged. However, the state subsequently imposed requirements for a type approval certificate to manufacture and sell an e-Rickshaw.<sup>58</sup> Consequently, many small-scale manufacturers were marginalised as obtaining a 'type approval certificate' was costly, but they continued informally.<sup>59</sup> Some of the excluded aggregators in the old city of Delhi created a new informal battery-driven vehicle (we call it *battery-jugaad*), which later diffused to other areas of Delhi and the neighbouring state of Uttar Pradesh. The *battery-jugaad* was innovated by the informal sector actors who had linkages with the cycle-rickshaw community. They started with the makeshift motorisation of a cycle rickshaw using e-Rickshaw electronics and discarded parts of motorbikes (Figure 3a). Over the next seven years, the *battery-jugaad* saw three major design changes (Figure 3a-c, first, second and third generation respectively) and subsequently achieved the necessary level of fineness to fulfil regulatory norms required for formal registration (Figure 4a). People have transformed the *battery-jugaad* passenger vehicles into goods vehicles too (Figure 4b).

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<sup>57</sup> TNN, "E-Rickshaw Drivers Need No Education for Licence," *The Times of India*, November 30, 2014.

<sup>58</sup> "Discussion On The Motion For Consideration Of The Statutory Resolution ... on 3 March, 2015," *Sixteenth Lok Sabha*. Accessed from <https://indiankanoon.org/doc/28432998/> on 17 August 2025; *MoRTH*, "G.S.R. 27 (E)" (2015). The type approval certificate confirms that production samples of a type of vehicle will meet specified performance standards.

<sup>59</sup> TNN, "E-Rickshaws Everywhere but Most Illegal in Ghaziabad, Drivers Don't Have Permits Either," *Times of India*, January 31, 2023, <https://timesofindia.indiatimes.com/city/ghaziabad/e-rickshaws-everywhere-but-most-illegal-in-ghaziabad-drivers-dont-have-permits-either/articleshow/97469168.cms>. Last accessed on 3 December 2025.



Fig. 3 — Three generations of *battery-jugaad* from 2014 to 2023. (3a Screen Grab from Youtube Video (Top Left)<sup>60</sup>; b) (Top and Bottom Right) and c) (Bottom Left) Photographs by the authors.)

<sup>60</sup> Video showing ‘Battery-Jugaad’, uploaded on May 4, 2016, accessed 15 July 2023 from: <https://www.youtube.com/watch?v=Lj47SHjFBZ4> . Last accessed on 3 December 2025.



Fig 4 — a) *Battery-jugaad*, which are registered with transport authorities (Top Left and Right); b) Further transformation of *battery-jugaad* as a goods vehicle (Bottom Left and Right). Photographs by the authors.

### ***Battery-driven Paratransit and Jugaad***

The regularisation of e-Rickshaw was made possible as the state actors appreciated, acknowledged and accommodated the *jugaad* methods. The government allowed the use of existing motor vehicle parts' standards for standardising the e-Rickshaw.<sup>61</sup> This allowed and validated, to an extent, the repurposing of existing parts (particularly motorbikes) for manufacturing an e-Rickshaw. The validation of the use of existing motor parts to manufacture e-Rickshaws, in this way, made it easier to allow the registration of existing

<sup>61</sup> MoRTH. "S.O. 2590 (E)" (2014).

e-Rickshaw designs. They only required a ‘road worthiness certificate’ and a ‘sale certificate’ from the e-Rickshaw association.<sup>62</sup>

The Minister of Transport, India (MoT) highlighted the motivation for allowing such standardisation of e-Rickshaws in his speech given in the parliament. He told the parliament that during the process of e-Rickshaw regularisation, he had to overrule the experts’ opinions, arguing for new standards for individual e-Rickshaw components. To quote from the speech given in the parliament:

An important issue was to standardise each part... I took that decision after careful thinking. It is a decision that is already standard material in the market; it can apply in these rickshaws, and I have no hesitation to confess that if there is Honda's wheel, axle of TVS, something else from somewhere, it is possible.<sup>63</sup>

Clearly, the idea of standardising each part largely emerged out of a protocolised thinking. Being functionally successful in repurposing the parts from other vehicles, apparently, was not enough to convince the experts of the gratuitousness of revalidation. However, the minister, reportedly, sought only to focus on safety, instead of following the routine protocols of designing standards for each part, apparently, to keep the vehicle affordable. The minister further argued that:

Cheap good quality material’s pattern design should be recognised by testing it, there is no need to standardise every part of it. I had to override the file for everything. I said Don’t do it because the poor man can’t bear it. But did not compromise with safety. Called IIT Engineers, called all our Institutions..., some of the (e-rickshaw) design is allowed by the technical body of the Delhi Government.<sup>64</sup>

While taking such a decision, his purported emphasis was not to increase the cost of the design:

When we asked for its standards in our department... he said that they will have to make a new standard for each part... Then I called the technical team and told them that if each part is ready to standard, then the rickshaw cost of Rs. 70,000 today will cost Rs. 2 *lakh*. How can the poor run it? I said such decisions will not happen, we want to make decisions in the interest of the poor.<sup>65</sup>

<sup>62</sup> MoRTH, “G.S.R. 861 (E)” (2014); PTI, “Centre Extends Date for E-Rickshaw Registration till Dec 31,” *Business Standard*, June 19, 2015.

<sup>63</sup> Lok Sabha Secretariat, “Further Discussion on the Motion for Consideration of the Motor Vehicles (Amendment) Bill, 2014,” machine translation from Hindi, Accessed from <https://indiankanoon.org/doc/125465102/> on 17 August 2025.

<sup>64</sup> Ibid.

<sup>65</sup> Rs. Denotes INR. 10 Lakh = 1 Million.

The case of e-Rickshaw shows that people are capable of handling, repurposing and reorganising the technological knowledge that emerged from “big science.” The e-Rickshaw manufacturers repurposed, mixed-matched parts from different vehicle types. These small-time manufacturers were able to manufacture a machine wherein some of the designs were good enough to be allowed to ply on the road along with the formal vehicles, manufactured in factories.<sup>66</sup>

### ***Regulatory Marginalisation and Battery-jugaad***

The new regulations, however, created new fault lines and exclusion, leading to new avenues for the *jugaad* technologies to evolve. The effective exclusion of rickshaw aggregators provoked them to innovate, and the *battery-jugaad* was born. The *battery-jugaad* evolved in phases in small roadside garages, by people who were mostly without any formal education, and none could explain the theory of vehicle design. Like the evolution of autorickshaw in Cairo, the *battery-jugaad* manufacturers transformed/repurposed their existing technology, learned skills and experience to build motorised vehicles using discarded resources. Their major emphasis was on trial/error methods, “learning by doing,” and tapping into “localised expertise”/resources for innovating the vehicle. Notably, it took over 2 years to stabilise the design, which transformed the first generation of *battery-jugaad*.

We observe a certain degree of openness in the sharing of information and design prototypes among the innovators. Every manufacturer added their own elements and improvisations, which were later adopted by others. Like respondent R1(I,M,A,P) innovated the handle design, while he learnt the second-generation *battery-jugaad* from other people. In fact, he wasn't the original innovator but learnt about the vehicle by reverse engineering. Some manufacturers (Like R8(M,A) or R10(M)) hired mechanics who had earlier worked with *jugaad* manufacturers.<sup>67</sup>

Overall, these innovator manufacturers transformed the cycle rickshaw's design into a motor-driven vehicle, which required design changes to accommodate speed, acceleration, braking, and the additional battery weight. Like R1(I,M,A,P) started using the discarded battery packs from mobile phone telecom towers, while another manufacturer (R9(M,A,S)) used old EV car batteries. He (R1(I,M,A,P)) identified and retrieved working power cells in each discarded battery pack and with the help of local electrical mechanics, they assembled a battery pack for these rickshaws. The use of Li-ion dry batteries over lead acid batteries enhanced cost efficiency, which helped this rickshaw diffuse further (R9(M,A,S)).

<sup>66</sup> Hansson, “What Is Technological Science?.”

<sup>67</sup> On the product/people form of knowledge, see, for instance, Shekhar Jain, “Emergence, Adherence and Proliferation of Industry Level Standards: A Case Study of Aligarh Padlock Industry, India,” *African Journal of Science, Technology, Innovation and Development* 13, no. 7 (2021): 853–864.

The existing spare parts suppliers evolved to support this new artefact. The innovators/manufacturers initially used old motorbike handles and assembled a tyre. They had to modify the motorcycle handle to suit the needs of this vehicle. This shop floor modification, however, was not perfect and led to frequent steering breakdowns. This was resolved when the bike handle supplier (R11(P)) evolved to support this vehicle. This supplier came to the manufacturing shop floor to understand the design needs of the *battery-jugaad* and provided customised factory-made parts, which stabilised the *battery-jugaad* design.

In another instance, which depicts utilisation of local expertise, one e-Rickshaw repairperson (R7(I,M,R)) in Ghaziabad reverse-engineered a vehicle, along with a partner, having expertise in metal door making, to start making their own *battery-jugaad*. The repairperson used his skills gained with e-Rickshaw repair to do the electronics, while his partner translated his door-making skills to build metal frames of the vehicle.

### ***Triumph of Jugaad over Big Science***

The triumph of e-Rickshaw over *Soleckshaw* and the later evolution of the *battery-jugaad* motivates us to analyse *jugaad* methods within the framework of scientific knowledge. The triumph represents a successful development of a scalable innovation where the useful knowledge is largely generated and nurtured outside the boundaries of laboratory science. Despite rudimentary resources and, absence of theoretical knowledge, the manufacturers in the informal economy developed a product which, eventually, transformed the electric vehicle landscape in the country. Interestingly, the ethical consideration that human drudgery is unacceptable helped these vehicles gain social legitimacy.

At least I don't have a problem with these on principle. I have grown up wondering why manual rickshaws have not been banned yet. To me, they seem like a gross violation of human rights. So, the e-rickshaws look like a much-needed alternative to me.<sup>68</sup>

Certainly, such critical sentiments for the cycle rickshaw may not be universal. However, a large majority of people in our survey (75%) think battery rickshaws are more respectable and beneficial for the manual rickshaw pullers and help them lead a happy and healthy life.

Additionally, e-Rickshaws were cost-effective for users, which turned out to be the most sought-after aspect in a last-mile connectivity vehicle in the survey we conducted. Interestingly, being eco-friendly is not an exclusively favoured option as yet, which incidentally was a major claim of *Soleckshaw*. *Soleckshaws* were envisaged as a “green ” vehicle with solar panels and were not fully motorised. Solar panels added extra costs and

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<sup>68</sup> Umang Aggarwal, “E-Rickshaws at DU: An Unsafe Convenience?” *The Times of India*, January 7, 2014.

reduced the efficiency in comparison to the e-Rickshaw. The *Soleckshaw* were not fully open source and required licensing for manufacturing, while anyone could adopt and improvise the design of e-Rickshaw and *battery-jugaad*. The improvisation and adaptation are evident in the multiplicity of designs of these vehicles.

The success of e-Rickshaw and the evolution of *battery-jugaad* show that improvisation-based science can offer safe, scalable technological solutions and can gain social legitimacy. The widespread diffusion and mimicking of these vehicles clearly indicate the replicability of such knowledge. On the other hand, confining the technology of *Soleckshaw* within the regulatory boundaries of section 2(u) (battery power below 250 watts and speed less than 25 KMPH) restricted its success. Instead of trying to keep the design simple and “humane,” the scientists emphasised an over-engineered design with a focus on solar-based charging. The *jugaad* (techno) science of e-Rickshaw/*battery-jugaad* is intended to be useful, transparent and democratic in its design and manufacturing steps, eventually contributing to the goals of sustainability too.<sup>69</sup>

### **Rounding up: Towards “*Jugaad-Science*”**

*Jugaad* represents a set of methods in the (non-confounded) environment of actual use of the technology. It uses, to paraphrase Feyerabend, “now on one trick; now on another,” along with alertness of mind, knowledge about existing possibilities available in the immediate environment, and a dedication to solving problems in the surroundings. These acts could be a response to the persistent exclusions due to regulations, scarcity of resources, or a lack of theoretical knowledge. *Jugaad* involves careful maneuverings of existing technologies, adaptations through trial-and-error.<sup>70</sup> *Jugaad* involves and evolves through a complex, multilayered feedback mechanism. It has the capacity to diffuse, through improvisations and adaptations, across geographic spaces, through open feedback, criticisms and improvements. In the absence of much codified knowledge, it often embodies itself in people, places and products.

The people undertaking *jugaad* are not “fly-by-night” operators; rather, they adopt *jugaad* after careful consideration and review of the possible consequences of their actions. Effective *jugaad* involves repeated trials, iterations and learning from failures. Improvising available equipment (using old batteries) indicates that *jugaad* is not intrinsically averse to “big science;” rather, it actively seeks to repurpose, adapt and manipulate the outputs of big science, to cater to the demands for accessibility and affordability. In fact, needs, access and

<sup>69</sup> Goel and Singh, “Inside India’s Messy Electric Vehicle Revolution.”

<sup>70</sup> Hansson, “Science and Pseudo-Science.”

affordability are the key to *jugaad* in the informal space. Through this process, *jugaad* could delay technological obsolescence too.

The e-Rickshaw could replace *Soleckshaw* as the former didn't alienate the key human actors and sensibilities while trying to upgrade the technological complexities of paratransit vehicles. The *battery-jugaad* innovated in Delhi gradually diffused beyond the political boundaries of the state (and, perhaps, the country). The *Soleckshaw* was exclusionary in its vision, objectives, and process. Even though it sought to prioritise eco-friendliness by adding solar panels, it added frills that raised the cost, making it unaffordable.<sup>71</sup> This emphasises that technological science could do better by prioritising the needs of the context, instead of blind protocolisation, based on narrowly defined mandates or objectives.

An engagement with *jugaad* enriches our understanding of how failures contribute to the progress of science. Today, big science is often averse to reporting negative outcomes for public scrutiny,<sup>72</sup> while in *jugaad*, failures are out in the open, as their success, and each failure represents a possibility of enriching its methodological arsenal. Such incidents ideally motivate people to evolve, appreciate the fault lines and correct their methodologies.

The emerging scholarship on “slow science” and “small science” reinforces the criticisms against the so-called idealised science by engaging with the questions of how goals and methods of science respond to scale, context, access, inclusion and individual experiences and idiosyncrasies of scientists. Simultaneously, many technology historians push the meanings of science beyond theoretical and methodological “comfort zones” and propose the idea of “technological science.”<sup>73</sup> The confinement of science within idealist and rigid criteria creates missing people, too.<sup>74</sup> Such forms of exclusion create actors, sites and spaces of *jugaad*.

### ***Towards “Jugaad-science”***

The disquiet over confining science to its “idealised core” of universality and objective rationality has been evident, both in academic scholarship as well as in science activism. Invocation of terms such as techno-science, amateur science, citizen science, indigenous science, subaltern science, feminist science, small science, or slow science seeks to address

<sup>71</sup> IDFC, Organising *Intermediate Public Transport for an Urbanising India*.

<sup>72</sup> Sheila Jasanoff, “Transparency in public science purposes, reasons, limits,” *Law and Contemporary Problems* 69, no. 21 (2006): 21–45.

<sup>73</sup> Hansson, “What Is Technological Science?”

<sup>74</sup> Braidotti, *Posthuman Knowledge*.

the diverse kinds of marginalisation of actors, scale and space, allegedly, promoted by the idealised science.<sup>75</sup>

*Jugaad science*, along this line of thinking, would help us pay close and systematic attention to the processes of search and experiments observed in the non-confounding environment of actual use of a technology, by people seeking to solve problems in their immediate surroundings, without theoretical knowledge of science, predominantly using experiential knowledge, improvisations and a deep understanding of the environment. “Jugaad-science,” however, is not antagonistic to, and remains open to, using the products of mainstream science.

The sites of such scientific efforts would be most visible in the vast and growing informal economy across countries. *Jugaad-science*, presumably, prioritises need satisfaction, affordability and accessibility, and intends to foster simplicity and decentralised control of scientific activities. The *jugaad-science* pushes us to think beyond over-protocolised decision-making, to a heuristics-based science, guided by experience, judgement and ecological rationality.<sup>76</sup> This way, *jugaad-science*, perhaps, takes us closer to a more human-centred understanding of science.

## Acknowledgments

We most thankfully acknowledge the comments from the two anonymous reviewers. Along with these comments, the various discussions with the editors of the special issue have helped us consolidate the core argument of the paper. We gratefully acknowledge the discussion with the participants of the conference on Small Science: contemporary perspectives on small scale research.

## Competing Interests

The authors have declared that no competing interests exist.

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<sup>75</sup> Note, however, that the categories may not need to be mutually exclusive.

<sup>76</sup> Bhaduri et al. "Frugality in innovation processes: a heuristics-based perspective from the 'informal economy'."