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Introduction

THIS BOOK explores the early history of computing in India, charting how its scientists and engineers worked to build a self-reliant computer industry. In the first two decades after independence, these pioneers set out to establish India as a major global center for computing research and manufacturing. By the 1970s, this project seemed close to taking flight. Indian scientists and engineers had begun building computers that rivaled the best in the world, while the Indian government had expelled IBM from the country due to its exploitative business practices. The ultimate goal was to foster public-sector-led computer manufacturing, thereby reducing dependence on foreign governments and multinational corporations. However, by the 1980s, just as this vision of technological sovereignty seemed within reach, it was suddenly abandoned in favor of an opposing approach: providing back-end labor and services for corporations headquartered in the Global North.

What led to this change? Motivated by a curiosity about the unexpected trajectory of computing in India, *Computing in the Age of Decolonization* addresses three interconnected questions. How did computing figure in India's early postcolonial dreams of sovereignty? What challenges did the country's technocrats and scientists encounter in their pursuit of self-reliance in computing, and in scientific and technological research more broadly? And why did these experts eventually relinquish their original vision of technological independence? The answers to these questions reveal the power dynamics that shape global computing today, particularly the concentration of resources and expertise among a handful of corporations in the Global North.

That India is *not* a computing powerhouse may seem counterintuitive to some readers, particularly those in the United States, where nearly one in four foreign-born workers in science, technology and engineering are of Indian

origin.¹ In 2019, the US employed about 721,000 Indians in STEM fields, far outdoing the second-largest immigrant group, with only 273,000 workers coming from mainland China. Additionally, as of late 2021, Indian-origin CEOs led some of the most influential US-based technology corporations, including Twitter, Microsoft, Alphabet (Google), IBM, Adobe, and Palo Alto Networks.² At the same time, as recent immigration crises in the US have demonstrated, lower-tier technology jobs can be incredibly precarious. In 2020, Trump-era reforms threatened the immigration status of many Indian-origin employees, and tech layoffs in 2022 led to the termination of roughly 60,000 Indian-origin tech workers.³ In sum, then, while Indian tech workers make up an important part of the global computing labor force, their employment is often unstable and largely serves the interests of corporations based in the Global North.⁴

This was not the future that Indian policymakers hoped for, particularly in the early years of decolonization. They understood that without building local capacities for research and development, the country's brightest minds would inevitably be drawn to places that could offer them access to the most advanced technologies. Today, their fears have materialized, as a direct pipeline from India's publicly funded universities to Silicon Valley keeps US technology hubs staffed with Indian expatriates.⁵

What alternative did policymakers propose? Almost in unison, mid-century technocrats and economists across the Global South were willing to bet the fate of their newly decolonized countries on the hope that technology would accelerate national development. India's leading economists were no exception. In the first decade after independence in 1947, they held fast to the idea that rapid technology-driven industrialization was the only way out of centuries of colonial underdevelopment.⁶ Their counterparts in Latin America agreed; the Argentinian economist Raúl Prebisch, for example, argued that technology-intensive manufacturing offered mid-tier countries a path to catch up with their more developed counterparts.⁷ In the 1950s, 1960s, and 1970s, policymakers across the Global South adopted these radical economic ideas. Some even identified computing as a particularly important technological niche in which to position themselves and transform their national standing. This was the case in India, where the first generation of post-independence technocrats saw great promise in the future of computer technology, which they believed could ignite a range of political and economic transformations, including catalyzing fundamental research, improving industrial efficiency, and helping plan the economy.⁸

Yet, while there was broad agreement on the need to leverage technology to escape colonial underdevelopment, there was significant disagreement on the approach countries ought to take. These disagreements led to dramatically different outcomes. Today, South Korea and Taiwan exemplify how one version of this strategy benefited a few East Asian economies. Much like India, these countries aspired to alter their position in the global economic order. Consequently, they implemented a series of transformative policies that turned the region into a vital hub for computing research and manufacturing.⁹ In the 1970s and 1980s especially, the South Korean and Taiwanese governments strengthened their hardware manufacturing capacities, incentivizing local corporations to invest in research and punishing them if they did not. In contrast, by the late 1970s, the Indian government made dramatic about-turns in its strategy.

As I detail in this book, India relented under pressure from foreign governments, multinational corporations, and its own industrial class. It moved away from research and manufacturing and concentrated instead on offering low-cost IT services to a global marketplace. This shift explains why India is now the world's leading provider of inexpensive outsourcing and offshoring services, yet enjoys minimal benefits from more profitable advances in research, manufacturing, and development. India's experience with computing serves as a sobering reminder of the enduring after-effects of colonialism. In an uncanny echo of the colonial period, the postcolony produces the "raw material" of cheap labor and services, while new global centers control the more profitable "upstream" end of the value-chain. Computing has become the new cotton—India provides the raw labor that drives Global North research and manufacturing.

One way to evaluate the outcomes of the diverging policies of different countries in the mid- to late twentieth century is to examine how much computer-related manufacturing contributes to their economies today. In the twenty-first century, digital integrated circuits—or chips, as they are more commonly known—have emerged as the most profitable computing-related export commodity, far outstripping the value of all other computer components combined.¹⁰ South Korea's exports of integrated circuits make up 20.7 percent of its total national exports, bringing in 141 billion dollars annually.¹¹ Taiwan's exports of integrated circuits account for more than a third of its national total, valued at 165 billion dollars annually.¹² Together, these two countries have emerged as easily the world's two largest net exporters of integrated circuits. In stark contrast, India's exports of integrated circuits (its most significant computing-related export product) account for only 0.40 percent of the national export portfolio, bringing in less than 1.92 billion

dollars annually.¹³ Conversely, India imports over 20 billion dollars of integrated circuits annually, making it one of the world's leading importers of this critical computing component.¹⁴

India is, of course, known for its outsourcing and offshoring industries, but earnings in that sector pale in comparison to those generated by East Asian manufacturing.¹⁵ Moreover, outsourcing is far more advantageous to recipient countries than to providers—this disparity is built into the very rationale underpinning the business model.¹⁶ The profitability of outsourcing depends on maintaining vast global wage differences and limiting workers to repetitive tasks. Further, outsourcing and offshoring enforce dependencies on foreign corporations, which accrue enormous political power in host countries because of the jobs they bring and just as easily take away. Finally, since high-level tasks are seldom transferred overseas, outsourcing and offshoring rarely lead to any significant transfer of technical knowledge. Put simply, outsourcing and offshoring define a system through which foreign corporations take advantage of India's abundant supply of inexpensive labor to increase their own profits.¹⁷

This current state of affairs is not the future that industry architects envisioned. Early dreams of a self-reliant, dynamic computing sector have faded into a reality marked by brain drain, dependence on foreign corporations, and a skewed focus on providing services. The original aim of leveraging computing to catalyze scientific research, boost industrial efficiency, and help plan the national economy has slowly dissolved as well. *Computing in the Age of Decolonization* describes a journey marked by early ambition, transformative efforts, and an eventual divergence from a foundational vision of technological self-reliance. Framed in this way, the story of computing in India is also the story of the struggles of a newly decolonized nation-state striving for scientific and technological autonomy in an increasingly globalized world.

The Machines Themselves

In the early years of the field, from the 1950s to the 1970s, computers changed rapidly in function, shape, and size. Initially, these machines were used mainly for military purposes, scientific research, and census processing. However, their role soon expanded to include business applications as well as political and economic planning. During this fast-moving period in computing history, seemingly minor decisions about parts and components were critical, often determining whether a machine would achieve long-term success or quickly

become obsolete. An engineer's choice of memory technology, software, or method for encoding instructions could spell a machine's doom. On the other hand, if a design gained acceptance, it could quickly become standardized and eventually mass-produced.¹⁸

These design and engineering decisions were not made in a political vacuum.¹⁹ A small number of US corporations determined which components and parts became standardized, controlled the necessary supply chains, and refined manufacturing processes for large-scale production. Scientists and engineers in the Global South, working outside this network, had to design and build their machines with only a fraction of the resources available to their American peers. Moreover, for machines produced in the Global South to be practical, they had to meet the standards established by US laboratories and corporations. This was especially challenging: pioneers in peripheral economies not only faced competition from an influx of outdated, used, mass-produced machines from the United States, which threatened to flood local markets, but were also obligated to comply with the stringent specifications set by these same manufacturers.

By the 1960s, one corporation had become a symbol of this unilateral power of US corporations to dictate the terms of global computing. As Emerson Pugh writes, "No company of the twentieth century achieved greater success and engendered more admiration, respect, envy, fear, and hatred than IBM."²⁰ Between 1950 and 1970, IBM machines became synonymous with the very idea of commercial computing. Moreover, while IBM faced some competition within the United States, its competitors were content to cede control of Global South markets—where, thanks to its unparalleled resources, IBM quickly established unchallenged monopolies. As Al Williams, president of IBM between 1961 and 1966, quipped, "They [IBM's competitors] are fighting us so hard here that they're not even thinking about overseas. Wait until they find out how thoroughly [IBM] World Trade has gotten itself entrenched."²¹

Thomas Watson Jr., who led IBM's charge into electronic computing, decided early on that "cultural difference" made Indian engineers unsuited for electronics research; he preferred to hire North Americans and Europeans.²² Of course, he failed to consider that what put him off about Indians was not "cultural" but the consequence of two centuries of colonial underdevelopment of engineering in India. His prejudice did not stop him, however, from eyeing India as a prime captive market for IBM's products. Because of Watson and Williams's aggressive efforts, IBM spent tens of millions of dollars between 1959 and 1962 to expand its global footprint, before other US corporations

even got their foot in the door. By the 1960s, it had flooded not only India, but a significant number of newly decolonized countries across the Global South, with outdated machines sold at marked-up prices, exploiting the lack of regulatory pushback and the absence of well-funded competition.²³

Like their peers in many parts of the world, computer architects in India found themselves caught in a dilemma. On the one hand, IBM was overwhelming the Indian market, even as it established new standards and protocols that rendered competing products incompatible and obsolete. On the other hand, India's technocratic policymakers demanded that engineers design state-of-the-art computers locally, with little outside help. All this—it bears repeating—while they worked with a fraction of the resources available to their global competitors. These two trajectories merged in the history of one of the machines this book examines in depth: the Tata Institute of Fundamental Research Automatic Calculator (TIFRAC). The TIFRAC was India's first advanced digital computer, built by a small team of engineers at the Tata Institute of Fundamental Research (TIFR) in Bombay to aid the work of the institute's physicists. No one on the TIFRAC team had ever seen a working computer before. Yet, the institute's leaders, entranced by dreams of complete technological self-sufficiency, forbade the team from employing foreign experts and held back the funding needed to import parts.

This commitment to self-reliance might seem naïve, especially since so much of global computing expertise at the time was concentrated in the United States. But it makes some sense when placed within the political context of the time. Many of India's new technocratic leaders had seen firsthand how colonial rule had kept the country in a state of technological stagnation, severely limiting its capacity for economic growth. The British had certainly brought European machines into the country, but had restricted them to European use.²⁴ This was part of the colonial mission's broader effort to protect its own technologically advanced manufacturing centers in the UK. Despite all their claims of modernizing South Asia, the British deliberately blocked the transfer of technological expertise from the metropole to the colony.

Independent India's new leaders aimed to avoid precisely this kind of dependency. They understood that to develop the national economy, they had to foster local capacities for scientific and technological research. Consequently, immediately after independence in 1947, India's postcolonial government prioritized policies to rapidly industrialize the country. Motivated by similar concerns, in the aftermath of a mid-century wave of democratization

movements, left-leaning economists across Latin America and Asia proposed the theory of import-substitution industrialization (ISI). In essence, ISI entailed incentivizing and subsidizing domestic manufacturing, in order to reduce dependence on foreign imports.

In many ways, the TIFRAC was import-substitution industrialization materialized in germanium diodes and vacuum tubes. By pushing a small team of engineers to build a machine locally, the leadership at TIFR aimed to achieve for computing what national planners sought for the broader economy: reduced dependence on trade and foreign aid. This ambition came at a high price. The TIFRAC was indeed built and, for a brief moment, seemed to validate the institute's ambitions for complete self-reliance. But its success was fleeting. The machine was decommissioned just three years after its official inauguration.

What went wrong? That question is best answered comparatively. The TIFRAC was designed to compete with IBM's newest computers. But IBM had a wealth of capital and technical resources at its disposal, allowing it to future-proof its machines by experimenting with features, refining designs, and iterating the manufacturing process as often as necessary. TIFR could not afford such design luxuries. It lacked the funds to build even a second machine if the first had flaws, or required critical upgrades.

With only one shot at success, the TIFRAC's architects took a significant risk. To stay competitive with IBM's latest machines, they incorporated an expensive piece of hardware: ferrite-core memory. Not only that, they attempted to build a significant portion of this cutting-edge memory in their own workshop. This was a gamble because the technology was incredibly expensive, out of reach for many of IBM's global competitors.²⁵ In this regard, TIFR succeeded where many Global North corporations had failed—the TIFRAC matched IBM's initial offerings in both speed and processing power. However, just as the TIFRAC was completed, IBM leveraged its capital to mass-manufacture ferrite-core memory at a low cost, while also seizing control over the supply chain for the necessary raw materials. Capitalizing on this advantage, IBM designed software that required ever-increasing amounts of ferrite-core memory to operate. The TIFRAC's engineers had taken their best shot, but with no resources left, they could not compete with IBM's standardization of larger memory capacities. Their machine worked, and it was undeniably fast. But constrained to a fixed amount of memory, it could not run the software needed to make it useful for the scientists who wanted to use it. Consequently, within a few years of its commissioning the TIFRAC went from being a state-of-the-art machine to a

“non-standard” device, more a technological curiosity than a practical computing tool.

From that moment on, every design choice, every component, and every piece of code that went into making Indian computers would be evaluated alongside machines manufactured elsewhere. The success or failure of these efforts would no longer be measured by ideals of technological self-sufficiency or autarky. Instead, with IBM machines flooding Indian markets throughout the 1960s and 1970s, Indian computer makers faced the challenge of convincing policymakers and customers that their machines were just as powerful as those manufactured by IBM. This was a tough sell, given IBM’s overwhelming advantages in capital, expertise, and manufacturing scale—to say nothing of its unrivaled market access and its unparalleled control of global supply chains.

It is important, however, to emphasize that the TIFRAC was not a complete failure. It proved that Indian engineers could build advanced computers at remarkably low cost. Nevertheless, its unexpected obsolescence forced TIFR’s leadership to learn hard lessons about global business monopolies and the importance of state protections and subsidies—lessons they later took to their roles in government in the 1970s.

From the Laboratory to the Nation

Many people and institutions shaped the early trajectory of Indian computing. Rather than attempt a comprehensive, sweeping account of all these actors and institutions, this book focuses on one key group of scientists and engineers, all of whom worked at the Tata Institute of Fundamental Research (TIFR) in Bombay. It was within TIFR that a vision of self-reliance in computing was first conceived and nurtured in India. As a result, despite their relatively small numbers, TIFR’s scientists had an outsized impact on the field’s trajectory.

My analysis spans from 1945, when the institute was founded, to 1980, when its leaders were forced out of the Department of Electronics, the government’s main policymaking body for computing. In the late 1940s, the institute called on postwar international organizations, including UNESCO, to send India an advanced computer for scientific research. However, its efforts were thwarted at the last moment by intense pressure from the US State Department. This setback made TIFR’s leadership acutely aware of how Cold War politics influenced the availability of foreign technical assistance. In response, in the mid-1950s, TIFR changed tack and pursued a new goal of complete

technological self-sufficiency. Driven by the spirit of import-substitution industrialization, it took on the ambitious task of building India's first advanced computer, the TIFRAC, from the ground up. However, a domestic economic crisis soon revealed the limitations of this approach. The inability of TIFR's engineers to import critical parts necessary to upgrade the TIFRAC convinced TIFR's reluctant leadership that complete technological independence, particularly in the fast-moving field of computing, was an unrealistic hope.

Consequently, the institute changed tack once again in the early 1960s, partnering with select US-based corporations, especially those eager to challenge IBM's global monopoly. This compromise aimed to use a handful of imported computers to catalyze local research and development. However, unfavorable trade conditions, volatile upheavals in domestic politics, and IBM's continued dominance got in the way once again. Finally, in the 1970s, in a last throw of the dice, TIFR entered government policymaking, hoping to leverage the state's regulatory powers to steer the computing industry toward self-reliance. This time, its efforts were thwarted by domestic private capital, which was far more keen to align itself with foreign corporations rather than the Indian state.

One might easily conclude from this litany of failures that the Indian state should have left computing well alone and allowed private capital—both foreign and domestic—to take the lead from the start. After all, today, India's outsourcing and offshoring industries are largely run by private firms in collaboration with foreign partners. Why did TIFR's early leadership want to have it any other way?

Scholars, computer pioneers, and journalists who have delved into the history of computing in India often raise this question.²⁶ If there is a common thread in the literature, it is that the Indian state's bumbling interventions in computing delayed the country's inevitable emergence as an IT services powerhouse.²⁷ Such accounts, often tinged with disappointment, criticize TIFR's involvement in government for ensnaring computing in bureaucratic red tape. This prevailing narrative suggests that Indian computing only began to flourish after state regulations were lifted in the 1980s.

This book offers a narrative of Indian computing history that sharply departs from the received wisdom. While existing histories provide useful overviews, they often overlook the core purpose of a developmental state like India: to transform the economy and spur industrial growth. As I noted above, Indian leaders, drawing on theories of import-substitution industrialization,

believed that computing would generate profitable returns, create jobs, persuade highly skilled engineers not to emigrate, and build regional capacity for scientific research. Objections to state intervention in computing miss this transformative rationale entirely.

Further, the fact that India's experiment with state intervention did not quite work out as planned in no way delegitimizes the approach. Other developmental states in Asia were remarkably successful in guiding domestic industries toward technology-intensive research and development. Consider, for example, the experiences of South Korea, Taiwan, and Japan, as described by the economists Alice Amsden and Robert Wade, amongst others.²⁸ Amsden has shown how East Asian states, particularly South Korea and Taiwan, gained their current, prominent positions in computing precisely by implementing national protections, subsidies, and state-led investments in key industries. Similarly, Wade reveals how East Asian governments—particularly in Taiwan, South Korea, and Japan—played an active role in reshaping their national economies, intervening in markets, and guiding domestic capital. Today, the results of state intervention in East Asia are strikingly clear.

I highlight these national projects simply to emphasize that, in mid-twentieth-century development projects, state intervention was almost a given. Newly decolonized countries and developing economies recognized the perils of an unfettered free market, especially when developed countries seemed to hold all the bargaining chips. Rather than play it safe and continue producing cheap raw materials for a global market, some newly decolonized states gambled their futures on competing with their Global North counterparts for a piece of the profits further up the value chain. For some countries, this gamble paid off; for others, it did not. The interesting question to ask of Indian computing, then, is not *whether* the state should have intervened, but rather *how* it did—and what it could have done differently.²⁹ What specific strategies did the Indian state pursue to ensure its technological independence, and what were their consequences?

Science and the New Nation-State

In the 1950s, India anchored its development strategy in the pursuit of scientific and technological self-reliance. Political leaders, technocrats, and scientists understood that formal political independence was not a sufficient

precondition for true economic sovereignty. Consequently, they were determined to break the country's reliance on foreign technological imports and catalyze domestic scientific research and development. Understanding their conviction requires tracing the deep impact of British colonial rule, which systematically impoverished India—especially through policies that enforced technological dependence.

In *Another Reason*, Gyan Prakash describes how the British colonial project strategically employed the empirical sciences to justify its rule.³⁰ Colonial officials produced detailed surveys, studies, and encyclopedias, mapping out India as a distinct, unified space, legible for colonial intervention. Further, they rationalized colonial rule by aligning it with science's ready association with progress. According to their reasoning, colonial domination was necessary to free India from its regressive feudal culture and usher it into technological modernity.

This idea—ruling to liberate, holding up science as both a means of control and the ultimate promise of universality—posed a curious paradox that proved the undoing of colonial rule.³¹ The British, in their bid to administer India, found it necessary to cultivate an intermediary group of educated Indians—not fully Europeanized, but sufficiently exposed to Western thought—to help them govern. Over time, this Western-educated elite began to perceive the fundamental hypocrisy of colonial rule. As Prakash puts it, “Enchanted by science, they saw reason as a syntax of reform, a map for the rearrangement of culture, a vision for producing Indians as a people with scientific traditions of their own.”³²

By the time this native elite assumed power, they had internalized associations between science, technology, and social progress that were once used to justify colonial rule.³³ After all, their caste privilege, class advantages, and educational opportunities had aligned them, in this respect, with the Whiggish propensities of India's colonial rulers.³⁴ At the same time, this small domestic elite's control over the country's vast population was far from hegemonic. The Indian state was not born out of a slow process of democratization or through revolutionary upheaval, but by colonial fiat. As a result, at the time of decolonization, technocratically-minded Indian elites inherited a disconnected, top-down state apparatus, without the consensus they needed to govern with popular support.³⁵ In this context of postcolonial instability, the promise of technological progress became central to the new Indian state's legitimacy, providing it with a political *raison d'être*.³⁶

This book draws inspiration from existing scholarship that highlights how science helped legitimize an elite postcolonial project.³⁷ However, my focus is on how this process unfolded in practice. For instance, India's nationalist leaders often outlined bold plans to transform the country through technology. Yet, as I demonstrate, the state's limited resources forced difficult budgetary choices, resulting in only modest investments in scientific research and development. Most Indian scientists operated in underfunded laboratories, lacking basic equipment and access to global knowledge networks. Computing was no exception. As policymakers sought to promote computing, their lofty ambitions led them to overlook the severe resource constraints they faced. I am particularly interested in the consequences of this gap between imagination and reality. More specifically, I explore the difference between what postcolonial leaders and technocrats *promised and claimed* (a topic that is widely studied) and what their scientists and engineers were able to *do in practice*.

The Tata Institute of Fundamental Research (TIFR) is an especially illuminating starting point for this inquiry. TIFR was led by India's most influential scientist at the time, Homi J. Bhabha. A rising star at Cambridge's Cavendish Laboratory in the 1930s, Bhabha was visiting India when the Second World War broke out and could not leave for the duration of the conflict. This led him to explore how he might launch a scientific career in his home country. In this, he was well served by close personal ties with India's most prominent industrial family, the Tatas. In 1943, Bhabha proposed the establishment of the institute that would bear their name, garnering support from both the Tata Trusts and the Bombay government.³⁸ Over time, TIFR came to be allied with the Department of Atomic Energy (DAE), a well-funded state scientific entity formed in 1954 to develop the nuclear energy sector, with Bhabha at its helm.³⁹ Yet, despite this advantage, TIFR struggled to secure government funding to support its computing projects, which were much lower on the state's priority list than nuclear energy development.

The history of TIFR captures some of the paradoxes inherent in the practice of science and technology in the early years of Indian independence. The institute represented both the techno-utopian aspirations of India's postcolonial leaders and the constraints that hindered them. Could TIFR's scientists, well-connected but underresourced, use their influence within the government to advance computing research and development? Ultimately, the answer would be shaped by India's geopolitical standing at the height of the Cold War.



FIGURE 0.1. Homi Bhabha explaining the TIFR building model to Prime Minister Jawaharlal Nehru in 1954.

Credit: TIFR Archives. Tata Institute of Fundamental Research (TIFR) / TIFR Archives has only provided the above image. The opinions expressed in the text are the author's own and do not reflect the opinion of TIFR including TIFR Archives.

The Global Cold War

In his groundbreaking work on the Cold War, Odd Arne Westad argues that both the United States and the Soviet Union sharpened an old colonial strategy, promising progress to those who supported their ideologies, while threatening violence to those who stood in their way.⁴⁰ For strategically important postcolonies, the promise of progress from both superpowers often came cloaked in the guise of technological assistance. Indeed, technological assistance rationalized the very idea of political intervention, much as it had justified colonial rule.⁴¹ However, postcolonial elites now wielded significant negotiating power. They could, to some degree, shape the terms of outside political intervention, and determine what technological progress meant to them.⁴² The question for historians of science, then, is: How did Cold War dynamics influence the patterns and priorities of scientific research around the world?⁴³ And, in turn, to what extent were postcolonial elites able to redirect and channel Cold War promises in pursuit of their own technological goals?

These questions are especially pertinent to the history of computing. Paul Edwards and others demonstrate that Cold War geopolitics significantly

influenced the funding, design, and use of computers, especially in their early stages.⁴⁴ Not only that: a country's status as an ally or enemy greatly affected its access to the latest developments in the field. By the 1970s, as Mario Daniels points out, high-performance computer exports were subject to stricter controls than nuclear reactor sales.⁴⁵ If India were to advance its computing ambitions, it would have to navigate these tricky Cold War waters.

India occupied an ambivalent place in Cold War geopolitics. The socialist leanings of India's early leaders—including its first prime minister, Jawaharlal Nehru, and the first TIFR director, Homi J. Bhabha—naturally drew them towards the Soviet Union. Meanwhile, a mutual distrust simmered between India's leadership and that of the United States. As Jerome Wiesner (a key architect of India-US technical relations) wrote on the occasion of Bhabha's death:

As a close friend and devoted follower of the late Prime Minister Nehru, Bhabha shared the great man's dreams, fears, ambitions, and viewpoints, including many that were not always understood or appreciated in the United States—neutralism, for example—and was often regarded as anti-American when he was indeed, only being pro-Indian. Because he was considered as anti-American, Bhabha sometimes was treated poorly by U.S. scientists who then found it surprising that he was often less than wholly enthusiastic about us and our ideas.⁴⁶

Wiesner and Bhabha were close friends, but when the former was appointed the Special Assistant for Science and Technology to the Kennedy administration, they clashed endlessly about how much influence the United States should have in dictating India's scientific priorities.

At the same time, Bhabha was pragmatic enough to understand that if he wanted to advance computing in India, he would have to take cognizance of the early dominance of the United States.⁴⁷ At first, he resisted US prescriptions about the kinds of developmental policies India should pursue. But, as the 1950s drew to a close, it became increasingly clear that there was no end run around the United States in the field of computing. By the 1960s, Bhabha tried to strike a delicate balance, seeking US technical assistance while continuing to resist the policy dictates that invariably accompanied that assistance. For its part, the US Congress viewed India as leaning towards the Soviet Union, making it less deserving of postwar economic aid. These suspicions grew after India's early recognition of Communist China and its neutrality during the Korean War. However, US policymakers also acknowledged India's strategic importance due

to its geographic proximity to both China and the Soviet Union. Consequently, albeit reluctantly, they approved substantial loan packages for India.

Initially, these loans came with strings attached. US policymakers urged the Indian government to focus on rural agricultural productivity and use the loans to import goods related to that primary purpose. The State Department was adamant that India tackle rural poverty before attempting any push towards industrialization. Skeptical global commentators saw this as a calculated move by the United States to discourage postcolonies like India from developing self-sustaining economies, steering them instead towards becoming markets for US-made industrial and technological goods.⁴⁸ The United States's further insistence that India use loans to boost private, rather than public, enterprise confirmed these suspicions.

Given this context, it is not surprising that US foreign policy circles not only disapproved of India's investment in heavy industry, but also viewed computing as entirely off-limits. This foreign policy consensus, paired with US misgivings about India's Soviet sympathies, severely hindered India's ability to acquire computing infrastructure and expertise from the United States in the 1950s and 1960s. The historian Nikhil Menon illustrates this point with the case of P. C. Mahalanobis, India's chief economic planner at the time.⁴⁹ Throughout the 1950s, Mahalanobis repeatedly attempted to import a computer from the United States for the Indian Statistical Institute in Kolkata. Yet, his undisguised Soviet sympathies led to the consistent rejection of his pleas for US support.

Mahalanobis was not alone in his preference for cooperation with the Soviet Union. Many of India's nationalist leaders favored the Soviets, in no small part due to the contrasting terms offered by the two superpowers for technical assistance. While US aid came with terms meant to dissuade India from rapid industrialization, Soviet support came with no such restrictions. In fact, Soviet aid focused on machinery and heavy industries like steel plants, aligning perfectly with India's vision of economic independence through rapid industrialization.⁵⁰ By the mid-1960s, Soviet aid agreements even included promises to import Indian-manufactured goods.⁵¹ This also aligned with India's long-term economic strategy: manufacturing would lead to exports, and eventually improve trade balances. The contrasting terms of US and Soviet loans created a remarkable disparity between the actual loan amounts and the resulting goodwill. Even though US loans were larger in absolute terms, Soviet loans were greeted much more warmly. The historian William Logan quotes the *New York Times* columnist Thomas Brady's 1965 complaint: "Soviet economic aid to India is less than one-fifth the magnitude of United States aid, but dollar for

dollar or ruble for ruble the Soviet Union gets about five times as much credit.”⁵²

Computing, however, was a different story. In the 1950s and 1960s, as the United States surged ahead in computing research and development, the Soviet Union, despite its achievements in other scientific and technological domains, lagged behind. This discrepancy may be attributed to a combination of factors, including the Soviet focus on military applications, insufficient industrial infrastructure, shortages of skilled personnel and materials, bureaucratic inefficiencies, and barriers to technological imports due to Western embargoes.⁵³ That discussion, however, is beyond the scope of this book. What is relevant is the constraint that Indian scientists and technocrats had to operate under during the Cold War period. If they were to garner external assistance to advance computing in the region, they would have to look to the United States, rather than the Soviet Union.

At the Indian Statistical Institute in Kolkata, Mahalanobis learned this lesson the hard way. Frustrated by several failed attempts to secure US assistance, he turned to the Soviet Union and its new flagship computer—the URAL. In the 1950s, a team led by Bashir Rameev in Penza developed the URAL, one of the first significant Soviet machines capable of processing complex mathematical problems and storing large amounts of data. However, by the 1960s, URAL development began to falter. A perfect storm of challenges—including a foreign trade embargo that blocked access to international computing advances, war-related labor shortages, and competing projects—hamstrung Soviet computing in general. The URAL also faced specific challenges of its own: limited production facilities for complex electronics, design variations causing performance and reliability issues, and a dearth of robust software, which made the machine notoriously difficult to operate.⁵⁴ These limitations were already well known by the time the URAL arrived in Kolkata in 1958. Barely a year later, the ISI’s leadership confronted a sobering reality. Their new computer could not deliver on its primary purpose: processing vast amounts of national statistical data quickly, accurately, and reliably.⁵⁵

At TIFR in Bombay, Bhabha took a different tack. He leveraged his connections with socialist scientists in Europe, forged during his time at the Cavendish Laboratory at the University of Cambridge. Chapter 1 details how Bhabha mobilized one of his close socialist allies in Britain, Joseph Needham, to help procure what would have been India’s first computer. Needham, who was appointed to lead UNESCO’s newly established science division in 1945, collaborated with Bhabha on a plan to use UNESCO funds to import a

computer for a new International Computation Center in India. In their view, this would catalyze computing in Asia, much as CERN catalyzed physics research in Europe. However, the US State Department, uneasy about the number of left-leaning scientists at UNESCO, thwarted these plans. They successfully lobbied for Needham's removal from UNESCO leadership and, at the eleventh hour, campaigned to have the planned Computation Center built in Italy instead of Bombay.

US involvement in Indian computing intensified over the years, exerting influence that extended far beyond import restrictions. After a punishing foreign exchange crisis in 1958, India was forced to accept loans from an aid consortium led by the United States, its allies, and the World Bank. The loans from this consortium were conditional; over the next few years, they forced India to devalue the rupee, dilute import-substitution policies, liberalize trade, and allow freer entry of foreign multinational corporations and private capital. Ever watchful for an advantage, IBM seized this opportunity and quickly flooded the Indian market with its computers. This meant that TIFR's efforts to manufacture computers would now have to reckon with increased competition from the global computing behemoth. This was not an equal fight.

A few statistics go a long way towards showing the material advantages IBM held over TIFR in the context of India's continued economic subordination. IBM's venture into electronic computing was driven by massive US government support, much of it funneled through collaborations with the likes of the Massachusetts Institute of Technology (MIT). These partnerships earned IBM over 2.8 billion dollars in the 1950s, which was roughly 7 percent of India's entire GDP at the time.⁵⁶ Meanwhile, India's scientific research funding was severely constrained, largely due to its colonial past. In 1949, just after independence, the country was spending a mere 0.01 percent of its national income on research and development (R&D).⁵⁷ Although the post-independence government made efforts to increase this allocation, pushing the figure to 0.4 percent by 1967, it was still only a fraction of what more advanced nations spent.⁵⁸ In absolute terms, in 1956, India's total R&D spending was only 0.3 percent of that of the United States.⁵⁹ As for TIFR, its entire institutional budget for its first decade was just over 1 million dollars, nearly a thousand times smaller than IBM's income from its military-funded collaborations with MIT alone.⁶⁰

This remarkable disparity highlights the challenges TIFR faced in its attempt to build a home-grown computer—the TIFRAC—in the mid-1950s.

While the TIFRAC had some design flaws, they could have been addressed by selectively importing components, which might have extended its operational life. However, US-backed aid conditions after the 1958 crisis made technological imports prohibitively expensive. As a result, the TIFRAC became obsolete almost as soon as it was built.

Foreign loans had additional negative impacts on technology transfers. The Indian government mandated that foreign multinational corporations (MNCs) like IBM partner with local entities when entering the domestic market. This was an attempt to maintain some control over the economy. However, this protectionism proved ineffective. MNCs retained control over their technological expertise, limiting skill diffusion amongst their Indian partners. These local firms were often relegated to specialized roles within the global supply chain. MNCs like IBM were able to continue to treat India as a captive market, while purposefully blocking the country from developing its own competing computing industry. The echoes of colonial-era science and technology policies could not have been more resounding.

Despite these daunting limitations, TIFR continued its efforts to build a home-grown computing industry. In 1962, with foreign loans now a staple of the Indian economic scene, Bhabha leveraged his position as the chairperson of the Atomic Energy Commission and secretary of the Department of Atomic Energy to divert a portion of a new USAID loan, originally designated for other projects, towards importing a computer for TIFR from IBM's leading competitor in the United States—the Control Data Corporation (CDC). TIFR's new plan was to reverse-engineer this machine, and to learn how to manufacture new ones that could compete with IBM's latest products.

TIFR, having learned from its experiences with IBM and the UNESCO project, approached negotiations with the CDC strategically. They secured key provisions to protect their interests and maximize knowledge transfer. These included on-site training for TIFR staff at the company's Minneapolis headquarters, with expenses covered and poaching of their personnel explicitly prohibited. Through these carefully negotiated terms, TIFR ensured that this technology transfer would provide not just an advanced computer, but also the technical expertise to operate, maintain, and enhance the machine independently.

TIFR's cordial partnership with the CDC was the exception that proved the rule. The CDC was keen to agree to all of TIFR's demands because it wanted to offer an alternative model to IBM's. TIFR and the CDC concurred

that IBM's presence in South Asia was damaging India's research and development efforts. Encouraged by their partnership, TIFR's leadership aimed to scale up their plans to the national level, taking on government roles to influence national policies. They had two goals: to advance local manufacturing and to force IBM to change its business practices. IBM, however, proved a canny antagonist and held the line against this effort. This conflict shaped Indian computing throughout the 1970s, culminating in IBM's departure from the country in 1978.

The complexities of India's computing history reveal a constant push-and-pull between externally imposed Cold War-era limitations and a series of often heroic efforts by Indian scientists and technocrats to push beyond those limitations. My attentiveness to these dynamics allows me to challenge simplistic narratives that portray postcolonial nations as passive recipients of global scientific largesse during the Cold War. The story *Computing in the Age of Decolonization* tells aligns with the findings of historians who have demonstrated that Global South actors exercised significant agency, even within the highly circumscribed environment of Cold War realpolitik. Framing Indian computing in this way highlights its non-linear and contingent trajectory. Indian technologists did not patiently wait for Cold War tensions to subside before pursuing their computing ambitions, and technology did not gradually spread from North to South of its own accord. This is a complex story of active engagement: a mixture of strategic calculation and accommodation in the face of often hostile global power.

Unsettling the History of Computing

The Global North continues to occupy center stage in the history of computing. Consider three of the foundational texts of the field: *Computing: A Concise History*, *Computer: A History of the Information Machine*, and *A New History of Modern Computing*.⁶¹ All three of these accounts begin with early precursors to the digital computer, then go on to discuss the earliest computers in the United States and Europe, then turn to the corporate development of commercial and military equipment, and finally arrive at the contemporary, networked world wide web. While commendable as introductions, these narratives, as the historian Michael Mahoney has noted, often resemble industry-insider accounts, laden with facts and records of "firsts," but lacking substantive engagement with the political and economic factors that influenced the field.⁶²

This book draws inspiration from Mahoney, particularly in its focus on the political and economic conditions so often overlooked in computing history. It explores perhaps the most neglected aspect of this story: how the development of computing in the United States was fundamentally *premised* on its underdevelopment elsewhere in the world. That the United States became a computing superpower, and that other countries were left behind, are not two separate facts. Nor are they a coincidence. One led directly to the other.

To prove this claim, I focus on India's earliest computers. I show how early postcolonial elites were as taken with computing as their peers in the Global North were. They embarked upon their own projects so that India might take the lead in the field. Admittedly, more often than not, these projects failed. But these failures, I argue, are a crucial part of the story of the rise of computing in the Global North. This is because postcolonial computing projects did not fail because of technical incompetence or cultural deficiency. Rather, they failed because Global North governments and corporations actively hindered computer pioneers outside Europe and the United States.

William Aspray was one of the few first-generation historians of computing to take an interest in this geopolitical dynamic.⁶³ He recognized that, for US-based corporations, computers were closely guarded proprietary secrets. Access to them, especially in other countries, was heavily restricted in order to reduce competition. At the same time, Aspray believed that the US government itself imposed relatively few restrictions on the export of computers, and that computing technologies spread relatively freely throughout the global scientific community.⁶⁴ While I concur with Aspray on the first claim, I disagree with the second. Explicit export restrictions on technologies earmarked for the Global South were indeed rare, but export restrictions were not the only way in which the United States government exercised its power. I detail the history of the UNESCO Computation Center project as one example of how back-room dealings by the US State Department held back the advancement of Indian computing. I also address indirect impacts of Cold War diplomacy and foreign policy that were as subtle as they were significant.

In situating computing within these broader geopolitical considerations, I am inspired by a second generation of historians who turned their attention to the Cold War. As Paul Edwards noted in 1996, the first generation of computing histories missed how Cold War politics became embedded in the technical design of computing machines.⁶⁵ Edwards's history of computing was among the first to locate the machine within its Cold War context. Historians of the Soviet Union like Slava Gerovitch and Benjamin Peters followed with

accounts that explained how the field developed on the other side of the Iron Curtain.⁶⁶ More recently, historians of computing have begun to explore the Global South, showing how varied national imaginations harnessed computing to their own agendas.⁶⁷

Eden Medina's 2011 book *Cybernetic Revolutionaries* remains one of the most compelling accounts in this tradition. Her analysis shuttles back and forth from Chile to Britain to account for the Allende government's creation of a computer system designed to facilitate real-time control over national productive capacity.⁶⁸ I am persuaded by her contention that "this broader geography of innovation [in computing] cannot be viewed as a discrete collection of national stories, for it is connected by the multidirectional and transnational flows of artifacts and expertise and the far-reaching effects of international geopolitics."⁶⁹

Computing in the Age of Decolonization builds on Medina's insights into computing as a national aspiration with transnational entailments, foregrounding the confluence of foreign actors and domestic imperatives. If the first half of the book follows these developments at the scale of TIFR, the second half expands the scope of my analysis to encompass the nation-state. As I noted earlier, TIFR's entry into government policymaking was prompted in part by its understanding of IBM's detrimental impact on Indian computing research and development. In 1978, TIFR and the government succeeded in expelling IBM from the country and standing up two domestic public-sector enterprises to pick up the slack. Within a few years, IBM's market share fell to a fraction of its original monopoly, and these two public-sector enterprises came to dominate Indian computer manufacturing.

However, this experiment in exercising technological sovereignty ultimately also failed. TIFR and its allies were hamstrung by resistance from an organized domestic industrial lobby, which wanted to make quick profits through software sales and back-end service provision to Global North corporations, rather than investing in capital-intensive research and development. By the end of the 1970s, this lobby campaigned successfully to exclude TIFR's scientists from policymaking. In the aftermath of this putsch, as public-sector enterprises lost all state subsidies and protections, IBM re-entered India, partnering with the Tata group to establish an operation that is now larger than its US headquarters. This new Tata-IBM joint venture led the charge to turn India into an outsourcing and offshoring hub.

Over the past decade, anthropologists have critically studied the consequences of this recent shift in Indian computing, examining how technology

workers navigate the inequalities inherent in these new labor dynamics.⁷⁰ Sareeta Amrute, for instance, shows how Indian software workers in Germany navigate the contradiction of living simultaneously as racialized migrants and globally mobile middle-class subjects.⁷¹ Similarly, Lilly Irani's ethnography of technology entrepreneurs in India captures how elites craft design projects ripe for corporate and financial investment, bending development imperatives to their own lucrative ends.⁷² Carol Upadhyia demonstrates how the Indian software industry transforms cultural difference into a sophisticated mechanism of labor control, reproducing class inequalities, while maintaining India's subordinate position in global technology relations.⁷³ Peter van der Veer turns to less elite ethnographic subjects, provocatively describing the most marginalized sections of India's IT virtual labor force as "techno-coolies"; he compares their aspirations and restrictions to those of indentured laborers in the nineteenth century.⁷⁴ In the same vein, Mary Gray and Siddharth Suri highlight the struggles of India-based tech workers who work as remote, low-wage "ghosts," creating—but never benefiting from—the profits of Global North corporations.⁷⁵

This growing body of anthropological scholarship illuminates an uneven distribution of technology work across a North–South divide. In this book, I offer a pre-history of how this unequal distribution came to be, while paying attention to the different future imagined by India's early policymakers. This was a future in which Indian engineers and scientists, protected from the predatory whims of foreign private capital, would work towards developing national, self-reliant infrastructures. Recognizing why this future failed to materialize requires a counter-historical approach that does not take the United States's dominance of global computing for granted, but rather excavates the historical contingencies that made it possible.

In sum, *Computing in the Age of Decolonization* joins recent efforts to unsettle the social scientific consensus on computing. Mar Hicks argues that the global computing economy has "long generated wealth through taking advantage of existing inequalities, existing infrastructure, and by using venture capital . . . to crush people who aren't in the driver's seat."⁷⁶ Scholars of postcolonial computing have taken this further, issuing calls to investigate the particular shape that these inequalities have taken in the Global South.⁷⁷ The intention here is not merely additive. I do not seek to diversify the scholarship by contributing new stories of innovation from "unexpected" corners of the world. Rather, I show how computing has always been based on transnational dynamics of labor and value extraction.

A Note on Decolonization

Sareeta Amrute makes a compelling case for the importance of writing histories and ethnographies of computing from the Global South.⁷⁸ For too long, she writes, the Global South has been unfairly portrayed as mired in a state of technological lack, with its scientists and scientific institutions not receiving the credit they deserve. However, Amrute warns against hastily labeling all histories that seek to remedy this state of affairs as “decolonial.” Following Walter Mignolo’s lead, she reserves the term “decolonial” for approaches that actively challenge Eurocentric frameworks and champion marginalized epistemologies and vernacular knowledge systems.⁷⁹

This book does not adopt a decolonial approach. The actors it follows were faithful, even to the point of zealotry, to the quintessentially Western idea that science, technology, and industrialization offered the sole means of escape from centuries of colonial underdevelopment. Self-avowed pragmatists all, they recognized technology’s role in colonial domination, but sought to repurpose it for postcolonial objectives. Inevitably, then, in telling their stories, I have sidelined a more radical and truly decolonial perspective: that the master’s tools—in this case, technologies that promise a quick fix to underdevelopment—will never dismantle the master’s house.⁸⁰

Moreover, most of the actors I track here were upper-class, upper-caste men who held positions of immense power and privilege.⁸¹ These men were complicit in perpetuating new forms of inequality. Kapil Raj’s research shows that during the early colonial period, Brahmins deliberately associated themselves with scientific research, claiming their expertise in classical texts made them natural heirs to modern scientific knowledge.⁸² By the early twentieth century, as Abha Sur demonstrates, caste hierarchies had become deeply embedded in the world of Indian science.⁸³ Almost all the scientists featured in this book retained their caste privilege while claiming that their pursuit of higher truths was socially neutral—a claim that warrants skepticism. As Satish Deshpande shows, upper-caste groups converted traditional caste capital into modern forms like lucrative jobs and advanced degrees over the course of the twentieth century. Having secured these advantages, they then kicked away the ladder of their caste privilege, presenting themselves as “caste-less” liberals.⁸⁴ Ajantha Subramanian’s research excavates how the idea of intellectual merit continues to disguise caste privilege among Indian tech elites.⁸⁵ And Renny Thomas’s ethnographic work reveals how caste-based hierarchies continue to dominate Indian laboratories.⁸⁶ All of these accounts expose a fundamental truth: that

caste privilege, rather than merit alone, continues to determine who is able to pursue—and profit from—science and technology.

Consequently, telling the stories of these actors does not meet the litmus test of a “decolonial” approach. But it does place a related term at the center of my analysis: “decolonization.” It does so because the burden of this book is to unpack the energies and ideas that drove a pivotal period in twentieth-century global history, in which vast swathes of Africa, Asia, and the Pacific emerged from centuries of colonial domination. As Gary Wilder notes, postwar decolonization was not merely a transfer of power, but an epochal process of global restructuring.⁸⁷ As new waves of democratization led to the creation of new nation-states, newly empowered postcolonial elites struggled to define the relationship between the postcolony and the ex-colonial metropole. Many among them were keen to sever ties of economic dependency. They concluded from their experience of colonial rule that it functioned, at its core, as a system of value extraction. They knew that colonial governments had deliberately arrested the development of science and technology in order to maintain this dynamic. The political and economic planners among them felt their task, then, was to quickly build up scientific, technological, and industrial capacity in order to compete with the West as equals. However, as they confronted the new world order—governed by postwar economic organizations and freely moving global capital—they found themselves facing a familiar, unequal fight. They believed that political independence without economic self-sufficiency was a hollow freedom, as it would inevitably be overrun by new forms of neo-colonial domination. The term “decolonization” in the book’s title highlights this postcolonial struggle to reinforce formal legal independence while simultaneously safeguarding scientific, technological, and economic sovereignty.

Here, Frantz Fanon’s critique of postcolonial elites is wonderfully helpful. Fanon was sharply critical of the nationalist consciousness that emerged after independence in former colonies, describing it as a “crude, empty, fragile shell” that served the ambitions of the new native elite rather than reflecting the people’s aspirations.⁸⁸ India’s nationalist bourgeoisie would have served extremely well as a target for Fanon’s ire. To maintain power, they aligned more closely with the capitalist class than with the growing labor movement and compromised with landed elites instead of pursuing genuine land tenure reform. This approach allowed them to consolidate their position while sidestepping the more radical changes that were likely required for them to fulfill their stated aims.⁸⁹

At the same time, the details of Fanon's critique are important. Part of his dissatisfaction with the nationalist bourgeoisie stemmed from the fact that they had no economic understanding, and failed to establish factories and profitable industries that would benefit their countries: "Independence does not bring a change of direction . . . the traffic of commodities goes unchanged. No industry is established in the country. We continue to ship raw materials, we continue to produce for Europe, and pass for specialists of unfinished products."⁹⁰ India's nationalist bourgeoisie, for all its shortcomings, cannot be accused of ignoring this close relationship between political and economic sovereignty. Their single-minded goal was to build an industrial base with which to change the country's economic fortunes. Their dream of advancing computing was a part of this broader, nationalist project. The term "decolonization," as I use it in this book, speaks to these energies, this drive towards a form of national self-determination securely and materially grounded in science, technology, and industry.

Both Fanon and the Indian nationalist bourgeoisie shared an understanding of how colonial rule systematically constrained colonized industries, ensuring that the colonies remained a source of cheap raw materials and a captive market for expensive finished goods. Imperial tariff policies let British textiles and machinery flow into India nearly duty-free, while Indian manufacturers faced steep tariffs when exporting to Britain. For example, procurement rules forced railways and public works in India to rely heavily on imported British steel, iron, and engineering products. Together, these policies systematically blocked Indian factories from competing on fair terms in the global market, leaving them largely confined to the domestic economy.

Nievas and Piketty drive home this point in a striking financial simulation on trade inequality, drawing on their World Historical Balance of Payments Database.⁹¹ Their analysis accounts for the notorious "Home Charges" India was forced to pay Britain for the costs of its own subjugation. Indian taxpayers funded British officials' salaries in London, the British military occupying India, and the metropolitan administration managing colonial rule. These transfers constituted the largest international wealth drain in the nineteenth-century world. Through rigorous quantitative analysis, Nievas and Piketty show that without these forced transfers, Europe would have become a massive debtor by 1914, with India and Indonesia owning substantial portions of British and Dutch assets. Absent colonialism, the colonized would have become the creditors, and the colonizers debtors.⁹²

These calculations reveal colonial policies as a massive redirection of technological possibility. The wealth extracted from India from 1800 to 1914 funded railways, factories, and labs that defined British industrial supremacy. Every pound drained via Home Charges and rigged trade meant Indian steel mills, technical colleges, and labs were never built. The Nieves-Piketty data transforms what historians suspected into mathematical certainty: Britain's rise was financed by preventing India's. This extraction funded Manchester's mills and Birmingham's factories while denying India its own infrastructure. Such theft of industrial capacity had profound consequences. When India achieved independence in 1947, building technological sovereignty became an act of historical reclamation. Every new scientific institution, from the Indian Institutes of Technology to physics research labs, was a correction to two centuries of enforced subjugation. Postcolonial industrialization was therefore both developmental policy and historical reparation.

These concrete comparisons underscore that colonial policies did not merely slow India's industrial growth; they diverted industrial and technological opportunity on a massive, measurable scale. British imperial constraints effectively transferred industrial wealth from India to Britain and, indirectly, to other industrialized nations like the United States, funding precisely the infrastructure and technological innovations that defined modern industrial economies. Such ledger-based evidence clearly maps the structural inheritance that independent India had to grapple with as it sought technological parity after 1947.

India's current computing landscape reflects the unfulfilled promise of decolonization—an era in which postcolonial leaders sought to stem the flow of wealth extraction from the Global South. While the scale of extraction is nowhere near as staggering as during the colonial period, the structural weaknesses left in postcolonial economies bear the deep imprint of an unequal colonial legacy. With regard to computing, for example, outsourcing and offshoring dominate, supplying skilled technical labor and services as the new raw materials in Fanon's analysis. What, then, became of the political experiment that aimed to transform formal independence into something more meaningful and enduring? This is a crucial question to ask today, as a particular strain of decolonization begins to reassert itself in parts of the Global South. Chakanetsa Mavhunga invites us to imagine a coming world order in which the African continent, for instance, finally unshackles itself from its unsustainable and unprofitable role in the current global order.⁹³ As Mavhunga sees it, a key axis of five hundred years of colonial domination in Africa was the West's

forced extraction of raw materials, which it paired with keeping the profitable privilege of value-added manufacturing for itself. In the present, Mavhunga contends, African countries are pivoting to value-added manufacturing, especially since it has become clear that chrome, cobalt, and lithium—all found in abundance on the continent—are vital to the world’s technological future. Mavhunga believes it is only a matter of time before African countries become centers of global manufacturing, add value to their own materials, and finally throw off the chokehold of Western dependency.

Revisiting decolonization as a historical process provides insight into the possibilities and limitations of reversing colonial inequities. Projects that aim to leverage new technologies to undo centuries of colonial and neocolonial dependency are both old and new. Lessons from the recent past will offer vital guidance to reparative projects, such as the one Mavhunga describes, in the present.⁹⁴ Although not decolonial in its approach, this book offers valuable insights into the global distribution of computing power and profit today. It focuses on the period of decolonization to learn from past successes and failures. Certainly, the critique of Eurocentric discourses of progress and development emerges here from within the Global North’s own framework, and not from the point of view of marginalized epistemologies. In the end, however, that may be a strength of my analysis, as I am able to illuminate, from within, a fundamental hypocrisy in Eurocentric discourses about science and technology: the notion that technological salvation is equally accessible to all.

Give Me a Laboratory, and I May Raise the World

The Tata Institute of Fundamental Research, or TIFR, is at the center of this book. I highlight this institute not merely because it was India’s most significant early hub for computing, but because it provides us with a compelling instance of how a scientific laboratory in a postcolonial context can profoundly shape a nation’s trajectory within a technological field. Bruno Latour famously quipped, “Give me a laboratory and I will raise the world.”⁹⁵ He meant that scientific work in a controlled setting could be strategically leveraged to reshape the broader social and political landscape. This phrase neatly captures TIFR’s efforts in computing, albeit with a crucial caveat specific to the postcolonial context. TIFR’s ability to “raise the world” was constrained in ways that Pasteur’s laboratory in France—the subject of Latour’s essay—was not. As an institution in a decolonizing nation, TIFR had to contend with the realities of resource scarcity, technological embargoes, and the expanding influence

of Western tech giants. From cosmic ray experiments to battles with IBM, from struggles with import licenses to dreams of silicon chip fabrication, TIFR's journey illuminates the fine line that divides scientific aspiration from the hard realities of building computing power outside the Global North.

Chapter 1, "The Ghost in the Machine," traces TIFR's efforts in its first decade. In the late 1940s, TIFR leadership—particularly Homi Bhabha and D. D. Kosambi—sought to partner with UNESCO to import an advanced computer. Kosambi, one of India's first computer pioneers, had already designed South Asia's first advanced analog machine but lacked funds to build it. The UNESCO offer thus came as a welcome opportunity. With UNESCO funding, Kosambi traveled to the United States to select a computer. However, while he was there, closed-door meetings at the US State Department effectively terminated support for UNESCO's initiative. This setback intensified TIFR leadership's skepticism toward foreign aid and steeled its determination to pursue technological self-reliance. This chapter sets the stage for TIFR's subsequent efforts to develop computing capabilities entirely domestically.

Chapter 2, "Cosmic Dreams," concerns the cosmic ray research program at the institute. TIFR's physicists developed a pathbreaking method to advance theoretical research in high-energy physics by substituting inexpensive domestically manufactured instruments for costly foreign apparatuses. Leveraging their small workshop, they developed innovative balloon technologies and cosmic ray detection methods, demonstrating TIFR's ability to compete internationally despite resource constraints. Eventually, however, these workarounds could only take them so far. Not having an advanced computer ultimately caused an insurmountable bottleneck, leading them to redouble their efforts to advance domestic computing research and manufacturing. At the same time, TIFR's encouraging success in building "homemade" experimental physics instruments gave its leaders the confidence to aim for a similar kind of autonomy in computer manufacturing. The same workshop that had cut its teeth on early physics instruments now turned its attention to assembling an entirely domestically-built computer.

Chapter 3, "Building the First Machine," traces the fate of this ambition to achieve computing self-reliance. In 1956, the institute began constructing a computer from scratch, relying solely on local expertise and resources. Remarkably, with very little of either, TIFR engineers succeeded in building a working machine: the TIFRAC. This computer, however, proved challenging to use. Much had happened in the world of computing between the project's inception and its completion. To update and standardize their machine in

accordance with new global computing protocols, TIFR's engineers needed to acquire some key parts and components that they could not manufacture themselves. However, a debilitating international financial crisis hit India just as the TIFRAC neared completion, putting an end to any hope the institute had of upgrading the machine. The TIFRAC's story illustrates both the potential and the limitations of TIFR's strategy to go it alone, setting the stage for the institute's more collaborative efforts over the next decade.

Chapter 4, "Partners and Predators," charts TIFR's response to these new technical and trade challenges in the 1960s. Over the course of that decade, the institute leveraged US financial aid to acquire an advanced machine, leading to the import of a state-of-the-art CDC 3600 from the Control Data Corporation (CDC). TIFR's intention was to use this machine as a catalyst to stimulate local research and development—a goal thwarted by a combination of unfavorable trade conditions, volatile domestic politics, and the increasingly dominant position of IBM. This chapter explores TIFR's strategic partnership with the CDC, which offered a potential alternative to IBM's monopolistic practices in India. It details the negotiations, hopes, and ultimate disappointments of this collaboration. The CDC's eventual departure from the Indian computing landscape left IBM with a clear monopoly that proved impossible to dislodge.

Chapter 5, "Self-Reliance 2.0," centers on another strategic pivot by TIFR in the 1970s. To challenge IBM's dominance, the institute's leadership entered the corridors of government, proposing and subsequently running the Department of Electronics. Through this organization, they sought to harness the state's regulatory authority to steer the computing industry toward a trajectory of self-reliant development. This chapter details the policies implemented by these bodies, including efforts to promote domestic manufacturing and place restrictions on foreign companies. It explores the creation of public-sector enterprises like the Electronics Corporation of India Limited (ECIL) and the eventual expulsion of IBM from India in 1978. However, once again, Indian technologists' efforts were stymied—this time by local private capital, which was more eager to form partnerships with foreign corporations, including IBM, than to align with the state.

Chapter 6, "Capitulation," traces how the dream of technological sovereignty collapsed amid the economic and political crises of the 1970s and 1980s. As the state's capacity faltered in the face of oil shocks and mounting global pressures, a new alliance emerged: domestic capital and new state actors joined with foreign multinational firms to prioritize quick profits and software

exports over domestic innovation. Regulatory authority eroded; state-led initiatives lost ground; and the project of self-reliance was quietly surrendered—transforming India from an aspiring technology producer into a global hub for technical service labor.

The concluding chapter, “First as Tragedy,” revisits India’s pursuit of technological sovereignty as a drama that unfolded first as tragedy—ambitious, hard-fought, and repeatedly thwarted by structural constraints—and then as farce, as contemporary claims to digital self-reliance merely repackage old dependencies in nationalist rhetoric. Through comparative analysis, it contrasts India’s fractured, compromise-ridden path with the institutional coherence and geopolitical fortune that enabled East Asian successes. Ultimately, the chapter argues that India’s celebrated status as a global IT powerhouse marks not the fulfillment of postcolonial dreams, but their hollow inversion—offering a cautionary lesson on how meaningful technological autonomy depends not on technical solutions alone, but on deep social and political transformation.

By reorienting our gaze to computing in the Global South, this book maps new terrain for the history of science and technology. Through TIFR’s journey—from cosmic ray research and the TIFRAC project to collaborations with industry and interventions in government policy—we follow the emergence and the complicated fate of a vision for technological sovereignty. This vision, rooted in postcolonial ambition, faltered amid the crosscurrents of Cold War geopolitics, the influx of global capital, and the priorities of domestic private enterprise. Framed against this backdrop, *Computing in the Age of Decolonization* rejects the popular misconception that technological innovations simply flow from the Global North to the Global South. Instead, this book invites us to reconsider the entangled power relations and histories that shape our digital present.

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