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INDIA POLICY FORUM 2022

VOLUME 19

EDITED BY
POONAM GUPTA, PRAVIN KRISHNA
KARTHIK MURALIDHARAN

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NATIONAL COUNCIL OF APPLIED ECONOMIC RESEARCH
New Delhi

NCAER 65

ACADEMIC FOUNDATION
NEW DELHI

First published in 2023 by

AF Press
No. 35, Sector 7, IMT Manesar,
Gurugram - 122 050, Haryana (India).
www.academicfoundation.org

National Council of Applied Economic Research (NCAER)
11 Indraprastha Estate, New Delhi 110 002. India.
www.ncaer.org

Academic Foundation is an imprint of AF Press.
Email: booksaf@gmail.com

ISSN: 0972-9755
ISBN: 978-93-3270-619-4 (PB)
ISBN: 978-93-3270-620-0 (eBook)

Typeset in 10.5 pt Times.
Typeset, printed and bound by AF Press, Manesar, Gurugram - 122 050.

PURPOSE AND ORGANIZATION

This 19th *India Policy Forum 2022 Volume* comprises papers and highlights of the discussions at the India Policy Forum (IPF) held on July 12–13, 2022. The IPF is organized by NCAER, the National Council of Applied Economic Research, India's oldest and largest, independent, non-profit, economic think tank.

The IPF promotes original economic policy and empirical research on India. The IPF Editors commission both empirical research papers and policy-focused expert reviews, the latter also based on robust, original research. It provides a unique combination of intense scholarship and policymaker engagement at the annual IPF Conference that reviews this research, leading to its eventual publication in this international journal.

An international Research Panel of India-based and overseas scholars with an abiding interest in India supports this initiative through advice, active participation at the IPF Conference, and the search for innovative papers that promise fresh insights, especially from younger scholars. An international Advisory Panel provides overall guidance. Members of the two IPF panels are listed below.

Papers appear in this annual *IPF Volume* after revisions based on IPF discussants' comments, a lively floor discussion, and the editorial guidance provided by the IPF Editors. To allow readers to get a sense of the richness of the conversations that happen at the IPF, edited discussants' comments as presented at the IPF are included here. The 2022 volume also provides hyperlinks to the video of each IPF session, including the floor discussion with IPF participants. Consistent with the editorial independence of the IPF, the papers and associated comments represent the views of the individual authors and do not imply agreement by the Governing Body, the IPF Editors, the management and staff of NCAER, or the IPF Panels.

The IPF 2022 also featured a Policy Roundtable titled, "Accelerating Formal Jobs, Higher Wages and Larger Firms", along with the 4th *T.N. Srinivasan Memorial Lecture*, titled, "Innovation, Experimentation, and Economics", delivered by Professor Michael R. Kremer, University of Chicago, and the *IPF Lecture* titled "Trade Policy for the Twenty-First Century", delivered by Professor Anne O. Krueger, Johns Hopkins University. The videos of the lectures are available at the hyperlink at the end of the Editors' Summary.

Rajnish Mehra *Arizona State University* and *NCAER*
Dilip Mookherjee *Boston University*
Sudipto Mundle *Centre for Development Studies* and *NCAER*
Karthik Muralidharan *University of California, San Diego* and *NCAER*
Ila Patnaik *Aditya Birla Group*
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Indira Rajaraman *Former 13th Finance Commission*
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M. Govinda Rao *Former 14th Finance Commission* and *NCAER*
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Nirvikar Singh *University of California, Santa Cruz*
Rohini Somanathan *Delhi School of Economics*
Arvind Subramanian *Brown University*
Arvind Virmani *NITI Aayog*

*All affiliations are as of April 2023.

CORRESPONDENCE

Correspondence about papers in this *IPF Volume* should be addressed directly to the authors (each paper contains the email address(es) of the corresponding author(s)). All author affiliations in the papers are as of the IPF Conference. Feedback on the IPF Volume itself may be sent to: The Editors, India Policy Forum, NCAER, 11 Indraprastha Estate, New Delhi 110002, or by email to ipf@ncaer.org. More information on the IPF is available on www.ncaer.org, including links to downloadable previous IPF Volumes and videos of individual IPF sessions for the past several years.

THE IPF TEAM

NCAER is responsible for the development, planning, organization, editing, and publication of the India Policy Forum Volume. The Editors are deeply grateful to the following NCAER staff for their major contributions in the production of the IPF 2022 Volume:

Anil Kumar Sharma	*Overall management*
Anupma Mehta	*Managing editor*
Jagbir Singh Punia	*Publication and production*

Additional thanks are due to the following group of people for their support in organizing and conducting the IPF Conference:

Abhishek Chaturvedi, Aditi Agarwal, Sanchita Kapoor, Geenu Pawa, Peeyush Gupta, Girish Khulbe, Khushvinder Kaur, P.P. Joshi, Praveen Sachdeva, Rajendra Lenka, Rakesh Srivastava, Ritesh Tripathi, and Sudesh Bala.

Editors' Summary

The India Policy Forum (IPF) marked its 19th year with its conference in New Delhi on July 12–13, 2022. The primary goal of the IPF is to promote original policy and empirical research on India. The annual IPF Conference provides a unique combination of intense scholarship and commentary on the research as well as a focus on its policy implications. The revised papers are published in this journal and benefit from a wide international readership. Over the past 19 years, interest in India has grown, to the point where there is now much more original research on India appearing in international economic journals. The IPF has also changed, making room for more policy-focused review articles that seek to define the best policy advice based on robust empirical research. It has also added more topical roundtable discussions of key policy issues dominating Indian economic policymaking and the economy in recent years. This annual journal of the IPF contains the five 2022 IPF Conference papers, the comments of the formal paper discussants, and a summary of the floor discussion of each paper.

This Editors' Summary contains summaries of the five papers presented at the IPF 2022 Conference, and ends with hyperlinks to the IPF 2022 program with onward links to the Conference versions of the IPF 2022 papers, video recordings, and presentations made in each IPF 2022 session, including the IPF 2022 lecture, the IPF Policy Roundtable, and the 4th T.N. Srinivasan Memorial Lecture.

Science-based Entrepreneurship in India: A Policy Glass (as yet) Quarter-Full

This paper by Tarun Khanna documents and celebrates the rise of de novo entrepreneurship in India in recent decades. Many of these new-age entrepreneurs are engaging in risk-taking to offer market-based solutions for product and service needs in the private and social space. However, this entrepreneurship is largely confined to a few sectors, and one of the most conspicuous lacunae is the absence of science-based entrepreneurship, which is seen globally as the source of long-term dynamism in advanced economies. The author argues that science provides the fuel for innovative entrepreneurship. This necessitates the establishment of higher education institutions that encourage innovation in education and local ecosystems that facilitate the application of science in entrepreneurial ventures.

The author also describes various recent policy efforts intended to address this gap. As of 2022, India attained the status of the third largest start-up ecosystem in the world, after the US and China, with the resultant 65,681 recognized start-

ups having created more than 700,000 jobs. The start-up scenario in the country is characterized by rapid digitization and the rise of Foreign Direct Investment (FDI). The total value of venture capital and private equity funding reached $38.5 billion in 2021. Further, the Securities and Exchange Board of India (SEBI) introduced a regulatory framework in 2022 that has reduced capital-related constraints by allowing loss-making organizations to disclose their Key Performance Indicators in the listing process. India has also witnessed a rise in unicorn companies, with 100 unicorns raising $90 billion and having a combined valuation of over $333 billion. Government initiatives like "Startup India" and the Atal Innovation Mission have further boosted entrepreneurship in the country.

The Atal Innovation Mission (AIM) has also led to various initiatives, including Atal Tinkering Labs and Atal Incubation Centres, aimed at fostering innovation and entrepreneurship. The Defence Innovation Organisation (DIO) promotes innovation in the defense sector, receiving support from AIM. It offers funding, partnerships, and access to resources for start-ups, with a focus on expanding its network and enhancing the defense innovation ecosystem. The Science & Technology (S&T) Clusters project creates collaborative ecosystems involving academia, the corporate sector, and local administration. The Program for Researchers on Innovations, Market-Readiness, and Entrepreneurship (PRIME) facilitates the transition of research to the market through virtual education and mentoring. The Biotechnology Industry Research Assistance Council (BIRAC) is also a positive initiative that has funded numerous med-tech companies, leading to successful product launches.

However, while these initiatives may be in the right direction, the investments they signify are inadequate and unlikely to achieve the desired level of science-based entrepreneurship in the country. Entrepreneurs also have to combat challenges such as educational gaps, limited outreach, lack of sustainable funding options, insufficient virtual platforms, and governance issues. Investments tend to be concentrated in e-commerce, technology, and financial services, with limited funding allocated to sectors such as healthcare, agriculture, and natural sciences. The lack of deep-tech start-ups and those backed by fundamental research indicates a gap in scientific advancement. Gender parity in funding remains an issue, with women co-founders and solo female founders receiving a smaller share of deals and funding. The incentive-based innovation infrastructure is underdeveloped as compared to that of other countries. The focus of the education system on rote learning hampers the development of entrepreneurial skills. Moreover, the weak enforcement of intellectual property rights and lengthy dispute resolution processes create hurdles for start-ups.

The paper emphasizes the need to overcome these challenges to ensure the attainment of robust independent research for scientific progress, innovation, and long-term growth. In the US, the research ecosystem is heavily reliant

on federally-funded research. These patents tend to be more cited and commercially valuable. In contrast, India's underfunding of basic research poses a major obstacle for science-based entrepreneurship. The country spends less than 1 percent of its GDP on R&D, which has been declining over time. Comparatively, countries like Germany, the US, and China allocate higher percentages to R&D, while leaders like Israel and South Korea dedicate over 4 percent of their respective GDPs to research.

Overall, therefore, though India has taken significant strides in its entrepreneurial ecosystem, it is imperative to address these weaknesses for fostering a more inclusive and diverse start-up landscape in the country. First, adequate funding needs to be organized on a priority basis for basic research. Insufficient R&D spending limits India's technological advancements and patent filings, with a smaller proportion of patents issued to Indian entities as compared to foreign ones. Industry and academia too need to collaborate for fostering innovative entrepreneurships. Successful international collaborations, such as the International Rice Research Institute and the International Space Station, have demonstrated the power of such partnerships in addressing global challenges.

Collaboration between research institutions and industry is crucial for driving innovation and technological progress. In India, there is need for high-quality incubators like the Incubation Cell of the Indian Institute of Madras, which is renowned for the numerous start-ups it has incubated, as well as the funding raised, patents filed, and jobs created. Some of the measures that can support start-ups include streamlining of patent processes, promoting education on intellectual property rights, and simplifying regulatory compliance requirements. Society, not just the government, must find ways to fund science-based start-ups originating from novel science. In addition, there is need for fast-tracking IP granting procedures, establishing specialized courts for IP disputes, and simplifying regulatory compliance requirements.

It is only by addressing the various challenges and implementing proactive measures for promoting science-based entrepreneurship that India can build a more inclusive, diverse, and robust start-up landscape.

Privatization of Public Sector Banks in India: Why, How and How Far?

This paper by Poonam Gupta and Arvind Panagariya suggests that finance is the lifeblood of an economy. Banks have a special role in ensuring that this lifeblood flows from the source where it is generated to the parts of the economy that exhibit the highest growth potential. This function assumes special importance in developing countries since the available finance is scarce and returns across projects show a high degree of variance. The problem is compounded by relatively underdeveloped capital markets in the early stages of

development, as this means that savers lack the instruments to directly invest in enterprises that promise high returns. Intermediation through the banks is their principal hope of earning decent returns on savings. In India, banks have done a generally poor job of lending, resulting in frequent defaults on repayments, and episodes of large accumulations of non-performing assets (NPAs). In turn, the government has had to repeatedly deploy massive volumes of taxpayer money to recapitalize the banks to jumpstart stalled lending and pre-empt financial crises. Central to these repeated NPA episodes has been the public-sector ownership of banks, accounting for three-fifths of banking assets. The NPA problem is primarily concentrated in these public sector banks (PSBs) and, indeed, they have been the sole beneficiaries of recapitalization financed by taxpayer money.

In principle, it is possible to reform PSBs while keeping their ownership in government hands but in practice, such reform has not happened and is unlikely to happen within the bureaucratic system of India. Hence, it is essential to focus on making the case for the privatization of PSBs and outlining the possible paths to it. The under-performance of PSBs has persisted despite a number of policy initiatives aimed at bolstering their performance during this period, such as recapitalization; constitution of the Bank Board Bureau to streamline and professionalize their hiring and governance practices; prompt corrective action plans; and consolidation through mergers, which helped reduce their number from 27 in 2016-17 to 12 currently. The Government infused $65.67 billion into PSBs between 2010-11 and 2020-21 to help them tide over the NPA crisis. Even after this massive infusion of funds, their NPAs remain elevated relative to private banks.

Strikingly, the market valuation of PSBs other than that of State Bank of India (SBI) (as on 31 May 2022) remains hugely below the recapitalization resources infused into them. Meanwhile, private banks have sped ahead by miles in terms of market valuation. The steady erosion in the relative market value of PSBs is indicative of a lack of trust among private investors in the ability of PSBs to meaningfully improve their performance. The authors' case for privatization of PSBs rests on the following grounds: (i) Private banks have consistently exhibited superior performance. (ii) The presence of PSBs potentially destabilizes private banks—this was evident during the Global Financial Crisis of 2008-09 when depositors turned to the implicit safety of the largest PSBs, particularly SBI. (iii) Government ownership of banks gives rise to many governance issues bearing on both the efficiency of bank operations and the ability of RBI to regulate the sector. (iv) Government ownership results in the flow of loans to serve political objectives. (v) Regular bailouts of PSBs cost the taxpayer vast sums of money. (vi) Government ownership gives rise to regulatory arbitrariness and ambiguities for all the three stakeholders concerned, that is, the PSBs, the Government, and the RBI.

The authors propose that the case for privatization applies to all PSBs, including SBI. But keeping in view its size and relatively better performance,

they suggest that the goal should be to privatize all PSBs except SBI for now. In the pathway toward privatization of all of the 11 PSBs, the first two banks chosen for privatization should set an example for the success of future privatizations. The banks chosen may be the ones with the highest returns on assets and equity, and the lowest NPAs in the last five years. To this, additional criteria may be applied such as the current government stake in the bank and its size. The lower the existing government ownership, the easier it may be to privatize any given bank. Likewise, politically the government may find it more attractive to begin the process of privatization with a bank that has a small asset base.

As regards the question of how to privatize, the most critical element has to be the withdrawal of the government from regulation as well as governance and management of the banks. All powers to regulate the privatized banks must pass on to the RBI. A private board with a strict cap on the number of government-appointed directors must have the sole responsibility to govern each privatized bank. Within the RBI norms, the power to appoint management and to set the salaries of all bank staff must be vested in the board. Government vigilance agencies must cease to have any jurisdiction over any of the bank employees. The first step for privatization to take place would be to incorporate the banks under the Companies Act of 2013, placing their operations under an RBI license, bringing government share in equity strictly below 50 percent, and transferring the governance of the bank to a board constituted under the Companies Act of 2013 and the Banking Regulations Act of 1970. The number of government-appointed directors on the board should be smaller of two and what is permitted under the law by the proportion of equity held by it.

With the proposed governance structure, the government may choose the level of divestment as per its comfort or revenue needs. For instance, it could retain as much as 49.9 percent of the bank's equity or divest its entire stake. There are two broad avenues to disinvestment. First, should the government choose to keep its stake near the 50 percent threshold and its existing stake happens to be less than 70 percent, it would need to divest only 20 percentage points of its shares. It may do so by publicly committing to selling 4 percentage-point shares on the 15th of each month for the required number of months beginning in a specified month. The commitment will have the immediate impact of raising the share price in the market and as the government makes good on its commitment, the price will move towards its expected post-privatization level. The government will thus be able to reap much of the benefit of the higher post-privatization price on the shares it chooses to divest.

The second avenue to sale is through a large strategic buyer or a consortium of buyers. Strategic buyers would foresee the post-privatization value of the bank from which the government would benefit through a competitive auction involving multiple bidders. The exercise of this option makes more sense in cases in which the government plans to sell a large stake in a bank.

The paper addresses two final questions. The first is whether there should be further consolidation of the sector through mergers before the process of privatization is launched. The authors see little scope for value creation through additional mergers. If anything, the government may find it easier to find buyers for small banks with their operations concentrated in specific geographical regions. The second question is: Who should be allowed to buy the banks? In the authors' view, the government must cast its net widely, allowing foreign investors including foreign banks and domestic investors, including domestic banks and corporate houses, to enter the auctions with due diligence. Any potential risks associated with corporate ownership or foreign banks may be minimized by letting a consortium of corporations enter the bidding with the stake of any single corporation capped; ringfencing the Indian banking operations of a foreign firm; and through appropriate regulation and supervision. If the status quo is maintained, it will lead to the following results: (i) The various constituencies of the PSBs will continue to be underserved; including the depositors of the banks, who would be deprived of higher interest rates, better customer services, and the benefits of digital banking. (ii) The productive firms will find it hard to get credit at market rates. (iii) The RBI will struggle with dual regulation and an impeded monetary policy transmission through the PSBs. (iv) The government will be saddled with poor valuations and demand on its limited fiscal resources. Eventually, these costs will have macro-economic implications of lower economic growth, slow progress in financialization of savings, and diversion of scarce resources from more worthy social goals.

Lessons from Disease and Economic Surveillance during COVID

In this paper, the author Anup Malani delineates the surveillance techniques used for monitoring both the disease and its economic outcomes during the COVID-19 pandemic. The paper also flags the lessons that these surveillance measures taught both the government and other stakeholders across the country. Finally, it offers some suggestions on ways of gathering credible intelligence, especially in the event of another pandemic. The over-arching learnings highlighted in the paper include the criticality of surveillance at the population level, the need for underscoring and providing effective incentives to implement such surveillance, and devising concomitant policies to deal with the pandemic.

The book, *The Age of Pandemics* by Chinmay Tumbe, argues that India has, in the course of history, suffered more fatalities from pandemics than any other country, including during the Spanish flu of 1918, and the outbreaks of cholera and plague at other times. The COVID-19 pandemic substantiates this hypothesis. Officially, India has 34 million cases and 500,000 deaths from COVID, while the actual numbers are expected to be much more. Estimates of excess deaths suggest that more than 5 million people may have died. The

pandemic also severely hit the economy, with poverty coming back with a vengeance, and persisting even after the national lockdown was lifted.

The paper outlines certain lessons that India ought to learn from its COVID experience, which would equip it to better face any other pandemic in future, be it Monkeypox or another variant of influenza. The author also reviews the nation's response to the pandemic, discusses attempts to track and arrest its spread, and examines various means to deal with future pandemics.

The various sections in the paper correspond to the different stages of the pandemic, that is, before the entry of the pandemic into India, the period prior to the lockdown, the lockdown itself, and post the lockdown. Thereafter, the paper discusses the surveillance strategies and associated policy responses, by addressing the following key questions: What did the government do? Why did it do so? What were the consequences? What could the government have done differently?

The author also suggests some policy reforms. He argues that both individuals and the government should be offered incentives for testing for infection, reporting the test results, and then acting to curtail the infection. The government, on its part, should watch out for the unintended consequences of policies like quarantine, while also creating a disease and economic surveillance infrastructure that allows for proactive measures even before the occurrence of the pandemic. These could include concerted efforts at sampling, refraining from making assumptions about the nature or course of disease, stocking necessary supplies, seeking the expertise and opinions of professionals, and learning ways to interpret various test results. It should also put in place an institutional design for tackling the health emergency, and facilitate effective functioning of all the agencies concerned. Further, the government needs to link disease surveillance with economic data in order to enable more accurate interpretation of this data. Last but not the least, it should ensure that policy is consistently based on disease and economic surveillance for it to be targeted and efficient.

As regards the lockdown, the paper avers that experience shows that once the high level of dispersion of the reproductive rate of the new infectious disease was confirmed, countries should have abandoned lockdowns and instead the targeted suppression only at individuals with high rates of infection, while offering the latter adequate financial compensation for keeping them away from work and livelihoods. Such targeted suppression may have helped control the disease with a less debilitating economic impact. Second, urban lockdowns ostensibly hastened the spread of the disease among slum-dwellers living in poor communities with high population densities. Third, lockdowns need to be accompanied by social programs to prevent spikes in poverty, leading to hunger and associated mortality from economic deprivation. The government should also step in to provide a safety net for vulnerable and indigent households through both food supply and cash transfers.

The author asserts that voluntary social distancing could also flatten the curve of cases, thereby negating the need for a forced lockdown. Unlike a mandatory lockdown, in voluntary distancing, individuals choose the amount of risk they abjure based on personal circumstances. This frees the poor to continue working if their economic losses outweigh the health gains from distancing. The data on symptomatic cases is also consistent with the argument that voluntary distancing can help keep the peak of the disease at bay.

On the issue of testing, the paper points out that India's experience with serological testing highlights several reforms that can help in preparing for the next pandemic. First, serological testing should be undertaken earlier in a pandemic, as it can inform population immunity better than antigenic testing. Second, there should be no barriers to both antigenic and serological tests, especially when these are employed for population-level surveillance as opposed to individual-level diagnostics for purposes of quarantine and treatment. This implies accepting and conducting tests approved by reliable foreign regulators, such as the US Food and Drug Administration or the European Medicines Agency. Tariffs on tests and testing materials should also be suspended once a pandemic has been declared. Finally, the drug regulator should encourage private laboratories to apply for the certification required to test for pandemics, and expedite the processing of such applications before the next pandemic, while enforcing measures to prevent the spread of infection among laboratory personnel.

As far as data is concerned, there is need for implementing a more credible mortality tracking infrastructure. It is imperative to regularly make public the data in death registries from all States. The Sample Registration System, which measures births and deaths in a representative sample of roughly 830,000 persons, is usually reported after a two-year delay, which prevents its use in policymaking. Hence, there is need to encourage private efforts, such as by the Centre for Monitoring Indian Economy (CMIE), to measure death rates.

The post-lockdown surveillance also highlights the need for economic reforms to prepare for the next pandemic. The government should eliminate barriers to migration and occupational change. In this crisis, the risk was from infectious disease. If in a future crisis, the risks were to come from husbandry or blight, the non-agricultural sectors could play the cushioning role that agriculture played during COVID. In this context, the government should encourage adaptation by all agencies, by limiting occupational licensing and regulatory hurdles to new business formation.

The paper concludes that the lessons presented in this paper would not be effective without a robust private sector, and active collaboration between the government and the private sector. As India builds its capacity to deal with the next possible epidemic, it would do well to stay away from excessive specialization and politicization of reasonable policy.

The US-China Trade War and India's Exports

In 2018-19, the US and China engaged in a trade war that targeted $450 billion in bilateral trade. The war ran counter to a multi-decades long endeavor that lowered trade and non-tariff barriers across the globe, and the share of US GDP targeted by tariffs was more substantial than the Smoot-Hawley tariffs. Market conditions for thousands of internationally traded products were upended, and analysts made predictions for how the trade war, and rising trade tensions more generally, would affect global trade.

This paper by Amit K. Khandelwal provides an answer to the question: Did the trade war increase India's exports? It examines India's response to the trade war from 2018–19. The author analyzes India's product-level trade data that cover the universe of its non-service exports. During that period, the US raised tariffs on Chinese exports in 4,413 six-digit Harmonized System (HS) products by an average of 23.1 percent, and China raised tariffs on US exports in 4,422 products by an average of 29.4 percent. Collectively, these two sets of tariffs covered 98.5 percent of India's (pre-war) exports. The two countries also changed tariff rates on bystander countries. The US raised tariffs on India's steel and aluminum products and removed India from the Generalized System of Preferences in May 2019. On the other hand, China reduced its Most-Favored-Nation tariff rates on bystander countries, so India faced lower tariffs on its exports to China. Together, these four sets of tariff changes constitute the "trade war", and the paper assesses how they affected India's export response to the US, China, and rest of the world. Through the lens of the model, the results offer insights into the underlying demand- and supply-side forces that drive India's trade. Moreover, the product-level responses can be aggregated to the overall country response to provide a summary of how India's exports responded to the trade war.

This analysis finds that India's export response to the trade war was quite noisy: an increase in India's global exports of 1.7 percent but with a large standard error of 3.6 percent. Thus, the analysis concludes that India's merchandise trade did not gain from increased trade tensions between China and USA. Moreover, there is no statistical increase in exports along a range of heterogeneous dimensions. The findings are consistent with claims that India, at least relative to its neighbors in East Asia (all of which are estimated to have benefited from the trade war), has difficulty integrating into manufacturing global value chains.

The overall disappointing lack of response should contribute to ongoing discussions regarding India's export strategy and the barriers that remain despite many improvements in the economic conditions for Indian exporters. Since the US-China trade war changed market conditions without India's consent, the normal considerations that weigh into a country's export strategy—the level of tariffs and non-tariff barriers—do not apply here. Although not the focus on

the analysis, the results instead suggest that continued domestic reforms are necessary for India to leverage opportunities in the global marketplace.

The paper concludes that the recent shocks to the world trade system, including Brexit, the US-China trade war, the COVID-19 pandemic, the Russia-Ukraine conflict, and increased nationalism in the West and China, have magnified geopolitical tensions. While these developments directly affect trade and investment in the countries concerned, the bystander countries are also affected. The author finds that the trade war raised India's exports by 1.7 percent but with considerable error around this estimate. There is some evidence that the tariffs increased firm entry into products, particularly for exports to the rest of the world, which offers some optimism that the trade war has created an opportunity for India to broaden its export base over the long run.

In addition, certain other questions need to be addressed: Were Indian firms aware of the magnitude of tariff changes in the precise product codes they export? Were they aware of how their competitors were responding? Could they find buyers in China or the US, and if so, through what platforms? Was trade financing difficult to secure? Did the products they export appeal to US and/or Chinese consumers? Given the challenges of contracting on specialized products, how easy is it for Indian businesses to build trust with buyers so that relational contracts emerge?

The author argues that such questions can be answered through tailored surveys which collect information on exporters' product quality, searching and matching frictions for overseas buyers, production structures, and constraints on factor markets can reveal the binding constraints faced by Indian firms in global markets. Hence, policymakers should be urged to create such surveys and launch targeted interventions for fully understanding and dealing with the challenges that Indian exporters face in global markets.

India's Services Sector Growth: The Impact of Services Trade on Non-tradable Services

The authors of this paper, Besart Avdiu, Karan Singh Bagavathinathan, Ritam Chaurey, and Gaurav Nayyar, study the effect of employment growth in tradable services on employment growth in non-tradable services, across Indian districts, between 1990 and 2013. India provides the relevant context given the rapid growth of its tradable services, such as software and business process outsourcing since the 1990s that started at lower levels of per capita income compared with the experience of countries before 1990. However, evidence also shows that the export of these services has benefited skilled workers more than unskilled workers in India. As a result, there are concerns that a labor-abundant economy, such as India, cannot rely on information technology-related

tradable services to facilitate structural transformation. These concerns can be alleviated, at least in part, to the extent that the growth of tradable services boosts job creation in non-tradable services that have accounted for much of the employment expansion in India since the 1990s.

The main challenge in analyzing the question is that time-varying unobservable district level characteristics may be correlated with district-level changes in employment for both tradable and non-tradable services. This would preclude the authors from making any causal inference on the strength of the relationship between growth in tradable and non-tradable services. They thus rely on changes in foreign demand shocks (world import demand changes) for tradable services that are otherwise unrelated to increases in employment in non-traded services, to obtain exogenous variation in their employment growth ("shift"). However, this exogenous employment growth in tradable services is common to all districts.

The authors depend on the initial district-level employment shares in traded services ("share") to obtain exogenous variation in the current district-level employment shares in these services. They therefore use a district-specific shift-share "Bartik-type" instrumental variable, which is the average change in world import demand—excluding India—for tradable services weighted by the initial employment shares of these services across districts. Using the instrumental variable strategy, they find that a 10 percent increase in tradable services employment leads to a 4.2 percent increase in non-tradable services employment. Furthermore, such an increase in tradable services employment increases the number of firms in non-tradable services by 2.8 percent.

The authors also assess the potential mechanisms driving the positive impact of the growth in tradable services on non-tradable services. Both the demand-side factors and inter-sector sectoral linkages may have played a role. On the one hand, growth in tradable services employment may have raised income levels which, in turn, results in higher consumer demand for local non-traded services (demand-side channel). On the other hand, growth in tradable services may have led to the growth in non-tradable services owing to strong input output linkages (inter-sectoral linkages channel).

The authors find suggestive evidence that demand-side factors rather than the supply-side factors explain the relationship between the growth in tradable and non-tradable services. First, they find that non-tradable services that benefit the most from tradable service growth have very low input-output linkages. Second, they find that household expenditure on key non-tradable services increased in districts that were exposed to larger increases in employment among tradable services. They also look at gender and firm size as two important margins of heterogeneity. They find that the magnitude of the impact is much larger for female workers; a 10 percent increase in tradable services employment leads to a 9.1 percent increase in non-tradable services employment for women as compared to 4.2 percent for men.

There are even larger differences between female-owned and male-owned firms. A 10 percent increase in tradable services employment leads to a 13.7 percent increase in the number of female-owned firms in non-tradable services as compared to a statistically insignificant increase of 1.6 percent for male-owned firms. Finally, the effects are only significant for small non-tradable service firms (for firms between 1-10 workers).

The paper provides new evidence on a dimension of structural transformation that is often ignored by policymakers who are most concerned with the movement of labor from agriculture to manufacturing. In India, the positive contribution of structural change to economic growth after the 1990s was largely attributable to the expansion of IT, Business Process Outsourcing (BPO), and other business services. The skill intensity of these tradable services, relative to manufacturing, has raised concerns that large-scale job creation, especially for low-skilled workers, is not as forthcoming. The growth of employment in tradable services is seen to have a positive impact on the growth of employment in non-tradable services. This impact magnifies the magnitude of employment creation associated with the growth of tradable services.

The 2022 IPF Lecture, IPF Policy Roundtable, and the T.N. Srinivasan Memorial Lecture

The 2022 IPF Lecture on "Trade Policy for the Twenty-First Century" was delivered by Anne O. Krueger, Senior Fellow at the School of Advanced International Studies, Johns Hopkins University, and the Herald L. and Caroline Ritch Emeritus Professor of Sciences and Humanities in the Economics Department at Stanford University. This session was chaired by Arvind Panagariya, Professor of Economics at Columbia University, and Visiting Distinguished Professor at NCAER.

The 2022 IPF also featured a Policy Roundtable on "Accelerating Formal Jobs, Higher Wages and Larger Firms", which was moderated by Manish Sabharwal, Vice-Chairman of Teamlease Services and member, NCAER Governing Body, with panelists Rajesh Aggarwal, Secretary, Ministry of Skill Development and Entrepreneurship, Government of India; Rana Hasan, Regional Economic Advisor at the Asian Development Bank's South Asia Department; Radhicka Kapoor, Senior Visiting Fellow, Indian Council for Research on International Economic Relations; and Sanjeev Sanyal, Member of the Economic Advisory Council to the Prime Minister.

In conclusion, the 2022 IPF hosted the 4th T.N. Srinivasan Memorial Lecture. Professor Srinivasan, who passed away in November 2018, was one of the IPF's most ardent supporters, not missing a single IPF over its first 15 years. His persistent focus on the quality of data and empirical analysis

remains a guiding theme for the IPF. The 2022 T.N. Srinivasan Lecture, titled "Innovation, Experimentation, and Economics", was delivered by Michael R. Kremer, Professor at the University of Chicago. Professor Kremer was the joint winner of the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel (Economics Nobel Prize) 2019, for "the experimental approach to alleviating global poverty". His work focuses on innovation, including in education, health, water, finance, and agriculture. The lecture was chaired by Bibek Debroy, Chairperson, Economic Advisory Council to the Prime Minister, with welcome remarks by Rajendra S. Pawar, Vice Chairman, NCAER Governing Body.

The videos of the IPF 2022 Lectures and Policy Roundtable are hyperlinked to the IPF program, which is available by clicking on this QR Code or visiting the URL: https://www.ncaer.org/IPF2022/agenda.pdf

To view the IPF program with hyperlinks to all IPF papers, slide presentations, and videos of all sessions, scan this QR code or use the following URL: https://www.ncaer.org/IPF2022/agenda.pdf

TARUN KHANNA*
Harvard University

Science-based Entrepreneurship in India: A Policy Glass (as yet) Quarter-Full§

ABSTRACT India is celebrated for a resurgence of de novo entrepreneurship in recent decades. Entrants have engaged in creative risk-taking to provide market-based solutions for private or social needs despite not being scions of wealthy industrial or business families. In this policy piece, I first document and celebrate this rise of entrepreneurship. I then turn to the inconvenient fact that this entrepreneurship is heavily circumscribed in a handful of sectors, even more so than the similarly skewed incidence that one sees in the US ecosystem (as an imperfect benchmark). A gaping lacuna is the lack of what I refer to as science-based entrepreneurship, increasingly understood as perhaps the key source of long-run dynamism of mature economies.

The academic evidence is compelling. Science, through the recombination of past insights, provides the fuel for innovative entrepreneurial economic output. This requires universities that are not ossified into traditional silos, as well as vibrant local ecosystems that allow the translation of science into entrepreneurship.

Then, I turn to relevant policy efforts underway in India within the last decade to address this lacuna. Preliminary data indicate that these experiments are likely on successful trajectories. They are, however, deeply insufficient in the magnitude of investment and policy ambition. The rhetoric and reality must be rethought if India is to capitalize on its deep talent reservoirs and move on from what I see as a glass yet only quarter-full.

Keywords: *Science-Entrepreneurship, Innovation, Policies, Investments*

JEL Classification: *L26, O30, O31, O32, O38*

* *tkhanna@hbs.edu*

§ This paper draws on the author's academic work and, more importantly, that of dozens of his colleagues in the US, Europe, and India. It is also informed by his experiences as an entrepreneur across the developing world and by his policy advocacy in India since 2015 through the good offices of NITI Aayog and the Office of the Principal Scientific Adviser (PSA) to the Government of India. Recent conversations with individuals from the Atal Innovation Mission (AIM); Office of the PSA to the Government of India; Ministry of Defence, Government of India; Delhi Science and Technology Cluster; and Indian Institute of Technology, Madras, were very helpful, as were discussions with Lee Fleming (Berkeley), Ramana Nanda (Imperial College, UK), Jasjit Singh (INSEAD, Singapore), and Chintan Vaishnav (NITI Aayog, AIM). Radhika Kak, Mansoor Masood, and Vidhya Muthuraman of the Harvard Business School, India Research Center, supported the writing of this paper.

1. Growth in Indian Entrepreneurship

As of 2022, India has the third largest startup ecosystem in the world after the US and China, with over 65,861 recognized startups that have cumulatively created over 700,000 jobs (Press Trust of India 2022) India's startup ecosystem development has been driven by a confluence of factors internal to the country (particularly the creation of a digital public infrastructure and the recognition by the State of the importance of entrepreneurship) and the vagaries of geopolitics and global capital flows.

There has been a 32 percent per annum growth in funding over the last decade. Venture Capital (VC) and Private Equity (PE) funding increased from

$3.1 billion in 2012 to a record $38.5 billion in 2021 (Bain & Company, and Indian Venture and Alternate Capital Association 2022) (see Table 1), with VC funding accounting for more than half of this. Both the number of deals and average deal size increased. Deal activity increased particularly in Series A, indicative of greater risk appetite for early-stage startups, and Series C and beyond, driven by multiple follow-on rounds by existing investors and an increased number of late-stage companies, both characteristics of a maturing startup ecosystem. More investors are participating in the startup ecosystem. The number of VC investors increased from 327 in 2012 to 455 in 2021 (see Table 1) (Statista 2022a). New members at angel investment firms rose ~7.5x between 2019–21 (Hariharan 2021).

TABLE 1. Startup Funding and Number of VC Funds in India

Year	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Number of VC funds in India	327	341	355	370	374	381	402	418	431	455
Total funding (US $ billion)	3.1	2.9	4.6	6.3	4.8	4.7	6.6	11.1	10	38.5
Average deal size (US $ million)	6.8	4.9	6.7	6.4	5.6	8.1	11.5	14.7	12.4	24.9
Number of deals	458	593	684	987	854	589	571	756	809	1,545
Number of deals by- deal size										
< US $10 million	N.A.	N.A.	N.A.	N.A.	728	485	410	543	637	1,135
US $10–US $50 million	N.A.	N.A.	N.A.	N.A.	115	89	136	171	128	270
US $50–US $100 million	N.A.	N.A.	N.A.	N.A.	4	3	8	20	24	48
> US $100 million	N.A.	N.A.	N.A.	N.A.	7	12	17	22	20	92

Source: India Venture Capital Report 2022 (Bain & Company, and Indian Venture and Alternate Capital Association 2022), SEBI 2018.

Note: The number of funds registered includes Registered Venture Capital Funds and Registered Foreign Venture Capital Investors.

Foreign investors are increasingly investing in Indian startups. Several factors have contributed to this. The Chinese startup ecosystem, India's biggest competitor, is highly saturated with too much capital chasing too few assets, while India's is relatively underpenetrated. US-China geopolitical tensions and the Chinese Communist Party's regulatory action against the country's tech ecosystem have also played a role. SoftBank, one of China's most prominent foreign investors, said it intended to take a 'more cautious approach' to back the country's startups' while it has continued to build its India portfolio (Rascouet and Pavel 2021). US-based Tiger Global, also a big investor in China, increased investment activity in India. In 2021, it was the second-largest investor by deal volume (Bain & Company, and Indian Venture and Alternate Capital Association 2022; Bhattacharya 2021).

Better prospects for secondary sales have also driven greater institutional investor participation in startups. The value of VC exits was a robust $14.3 billion in 2021, a far cry from scant exits in recent decades. The robustness was accentuated by this being a mix of secondary market strategic sales (60 percent of total VC exits) and primary capital raises through IPOs (40 percent) (Bain & Company, and Indian Venture and Alternate Capital Association 2022).[1]

The SEBI's 2022 regulatory framework, which proposed disclosure requirements for loss-making companies, has alleviated some of the capital constraints faced by startups and increased the number of VC-funded companies listing on Indian exchanges. The new framework made it possible for loss-making companies to release Key Performance Indicators (KPIs), along with the disclosure of the standard financial ratios, during the listing process. Companies had the discretion to determine the specific KPIs and justify their use (Securities and Exchange Board of India 2018).

SEBI's Innovators Growth Platform, launched the same year, and aimed at relaxing listing requirements for issuers in technology or IP intensive fields such as IT, bio-technology and data analytics, has also helped. The platform relaxes restrictions on pre-issue capital, allows discretionary placements of an issue and listing of shares with differential voting rights, and simplifies delisting requirements. Arguably, these are signs of somewhat greater investor sophistication and greater regulatory comfort with earlier stage and riskier assets becoming available in the market.

Higher valuations, too, have encouraged investors. In May 2022, India became the third country to produce 100 unicorns after the US (559 unicorns) and China (173 unicorns). India has seen an acceleration in unicorn generation; 44 unicorns emerged in 2021 versus 42 in China. In Q1 2022, India added 14

1. There was much exuberance around the recent IPOs of Zomato (a restaurant aggregator and food delivery app that raised approx. $1.25 billion), and Nykaa (an omnichannel retailer of beauty and related products that raised approximately $715 million). The resilience of these business models will become clear over time.

unicorns compared with 5 in Q1 2021. India's 100 unicorns have raised $90 billion and are valued at over $333 billion. They have acquired 326 companies and created employment for 380,000 people (Inc42. 2022).

The promulgation of government initiatives to nurture entrepreneurship has helped particularly by signaling the support of the State for the phenomenon. For example, the "Startup India" initiative, launched in 2016 under the Ministry of Commerce and Industry, is an important such endeavor (Government of India 2020c). The Atal Innovation Mission (AIM), also launched in 2016 under the NITI Aayog, and therefore equidistant from all ministries, is another. The AIM seeks to improve educational opportunities for school-aged children, promote R&D, and connect various stakeholders through a network of incubators.

A maturing digital infrastructure has been a catalyst, and is itself in a sense a result of an encouraging symbiosis between the State and private sector entrepreneurs. India is one of the few countries that has built digital public goods at scale. Unlike the US and China, where private companies and the government facilitated the creation of digital infrastructural assets, in India, a combination of public-private partnerships and volunteer-driven initiatives has contributed to the creation of digital platforms and technologies. An example of this is India Stack, a series of platforms that have emerged to solve constraints to financial inclusion and support the government's Digital India initiative. Through digital identification (Aadhaar), interoperable payments (the Unified Payment Interface), and data management, India Stack has led transformations in digital and financial inclusion. Aadhaar provided digital IDs to more than 95 percent[2] of the population and lowered the cost of verifying IDs, making it easier to deliver banking and other services (International Monetary Fund 2021). The Unified Payment Interface (UPI) has made bank-to-bank transfers free and seamless via mobile phone, accelerating the adoption of digital payments. This has helped digital services startups increase market penetration and e-commerce companies reduce cash on delivery orders. Over 22.3 billion transactions worth $547 billion were made through UPI in 2020–21, signifying a 78 percent increase in volume and a 93 percent increase in value from a year earlier (Reserve Bank of India 2021; Inc42. 2022). Furthermore, low data prices,[3] pushed down by market competition (Cable.co.uk 2022), increased internet penetration from 4 percent in 2007 to 45 percent in 2021, and monthly data consumption per user from 805 MB in 2015 to 17 GB in 2021 (Statista 2022b; Nokia 2022). The Aadhaar-driven electronic Know Your Customer (e-KYC) has enabled companies to evaluate credit histories more efficiently and offer financial products in a paperless format. Through all this, Bangalore has emerged as the startup hub of India, being listed in the top 10 startups cities in the world (StartupBlink 2022) and the third-best in Asia, behind Beijing and

2. Aadhaar enrolment data from UIDAI Annual Report 2020–21.

3. The cheapest GB of data in India is as low as $0.05.

Shanghai (StartupBlink 2022). In 2021, it accounted for half of all VC funds raised, 40 percent of all deals (Inc42. 2022), and was home to 14 of the 25 most funded startups (Entrackr 2021).

2. Weaknesses in the Indian Startup Ecosystem

Notwithstanding the progress, India's emerging entrepreneurial ecosystem continues to face considerable challenges.

Early-stage investments are disproportionately channeled into a few sectors. Over the last decade, investors predominantly invested in the e-commerce, technology, and financial services sectors, in that order, while other sectors like healthcare, agriculture, and ideas emanating from the natural sciences, received limited funding (see Table 2) (Indian Venture and Alternate Capital Association, Ernst & Young 2022; Entrackr 2021).[4] The fact that 65 of India's 100 unicorns are in the e-commerce, fin-tech, and IT-services sectors and not a single unicorn is based on advances in the natural sciences is a testament to this (Inc42. 2022).

TABLE 2. Startup Investments Split by Sector: 2011–20

Industry	*Number of Deals*	*Funds raised (US $ million)*	*% of Total*	
			Number of Deals (%)	*Funding (%)*
E-commerce	805	13,311	23.9	39.2
Technology	738	5,183	22.0	15.2
Financial Services	397	5,052	11.8	14.9
Logistics	209	2,044	6.2	6.0
Infrastructure	190	1,455	5.7	4.3
Healthcare	178	1,297	5.3	3.8
Media & Entertainment	174	915	5.2	2.7
Education	132	901	3.9	2.7
Real Estate	128	828	3.8	2.4
Food and Agriculture	126	746	3.7	2.2
Others	285	2,264	8.5	6.7

Source: India Trend Book 2021 (Indian Venture and Alternate Capital Association, Ernst & Young 2021).

A recent study of India's deep-tech startup ecosystem claimed that 12 percent (or approximately 3,000+) of India's startups in 2021 were deep-tech startups, i.e., startups that created, deployed, or utilized advanced technology like AI,

4. Between 2011 and 2020, there were 805 deals in technology, 738 in e-commerce, and 397 in financial services, but only 178 in healthcare.

machine learning, internet of things, drones, etc., in their products or services, and only a small pool of these startups (about 500) created products or solutions that were backed by fundamental research (NASSCOM and Zinnov 2022). The study classified these as 'inventive deep-tech' startups. These classifications are, to some degree, subjective, but it appears true that very few startups in India involve deep scientific advance (some sectors, like life sciences, are almost entirely absent) (NASSCOM and Zinnov 2022).

Gender parity in funding is also an issue. Between 2018 and 2022, startups with women co-founders accounted for 17 percent of the number of fundraising deals and 6.4 percent of funds raised. Solo female founders accounted for an even smaller share; 3.4 percent of all deals and 0.78 percent of funding value (YourStory Media 2022). Various government, corporate, and investor-led programs, like the NITI Aayog Women Entrepreneurship Platform,[5] the Telangana government's WE Hub,[6] and the Godrej group's Beauty-prenuer program,[7] have targeted boosting female entrepreneurship. Still, these initiatives are few and far between.

The competition and incentive-based innovation infrastructure is also anemic. Developed countries use incentives to boost innovation, particularly in science and technology. Some examples are the UK "Grand Challenges",[8] the US federal government platform, challenges.gov, and the competitions run by the Chinese government. In contrast, in India, competition-driven innovation is still emerging. While the AIM has launched a few competitions to promote innovation, and India recently began hosting a local version of Shark Tank, a US reality show that has inspired entrepreneurship in young adults (Roy and Aziz 2022), to rally support among the public for this kind of approach, these efforts to broad-base incentives are at an early stage.

Though incubators have been growing, their number and quality is as yet inadequate. In 2019, there were only 0.4 incubators and accelerators per million people in India, compared with 4.5 in the US and 2.1 in China. Further, many incubators are housed within academic institutions and operate in silos with insufficient interaction and partnership with the outside world. Hence, many early-stage startups miss out on the networking, mentoring, and funding opportunities most critical for success.

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5. A platform to provide women entrepreneurs funding assistance, mentorship, and other support. It currently has over 26,000 women and 200 partner organizations.

6. The Telangana Government's initiative to incubate women entrepreneurs by providing access to technical, financial, and mentoring support.

7. A program that supports small-scale women-led beauty enterprises by building technical and business management competencies, and creating a community of women to network, share and learn.

8. Part of the UK Government's endeavor to put UK at the forefront of the industries of the future. The first four challenges are AI and data, ageing society, clean growth, and the future of mobility.

Well-known gaps exist in the Indian education system. Its rigid emphasis on rote learning impedes students' creative and analytical thinking, practical learning, and communication skills. These skills are vital for entrepreneurship. A recent study found that despite consistent talent shortages in the IT industry, less than 20 percent of engineers are employable for software jobs and only 3.5 percent for core IT product roles (SHL 2019).[9]

Finally, notwithstanding the progress made to streamline regulatory processes by the introduction of the Goods and Service Tax, and self-certification for compliance with labor law under Startup India, the regulatory environment remains complex. Entrepreneurs have to deal with numerous agencies to obtain the permits required to start a business. Weak enforcement of intellectual property rights is an issue. Further, due to a backlog of cases and insufficient judicial capacity resolving disputes in Indian courts is a lengthy process. Early-stage startups spend considerable time and resources on regulatory issues, which diverts attention away from core business building.

3. Specific Institutional Voids Relevant to Science and Tech Entrepreneurship

In earlier writings, I co-developed (with Krishna Palepu) a simple taxonomy for thinking about the structural inadequacies that bedevil the bringing together of buyers and sellers to consummate transactions in so-called emerging markets. In other words, what particular combinations of information or contracting problems make a market 'emerging' rather than one that has matured or 'emerged' (Khanna and Palepu, 1997; Khanna et al. 2010)?

Relative to more mature economies, entrepreneurs in emerging markets find it difficult to access information about each other, evaluate credit histories, and credibly ascertain the quality of products and services. When disputes arise, contractual or arbitration mechanisms to resolve these are limited or inefficient. Mature economies rely on a network of specialized intermediaries such as independent auditors, financial and other analysts, media agencies, headhunters, a government to promulgate rules, and a judiciary to enforce them (see Table 3). We refer to the absence or paucity of such intermediaries as institutional voids.

With regards to science and deep-tech entrepreneurship in India, woeful informational and contracting voids in talent and capital factor markets manifest in several arenas, such as these below.

9. SHL's "National Employability Report: Engineers Annual Report 2019." Such reports were first published by the company acquired by SHL, based in New Delhi, called Aspiring Minds.

TABLE 3. Institutional Infrastructure in a Developed Market

Type of Market Institution	*Function that it Performs*	*Examples in Capital Markets*	*Examples in Product Markets*	*Examples in Talent Markets*
Credibility enhancers	Third-party certification of the claims by suppliers or customers	Audit committees; Auditors	ISO certification; CMM level certification	AACSB certification; ETS admission tests
Information analyzers and advisors	Collect and analyze information on producers and consumers in a given market	Financial analysts; Credit rating agencies for companies and individuals; Financial press; Financial planners; Investment bankers	Consumer reports magazine; J.D. Power ratings; Press; Industry analysts (Gartner Group); Market research firms; Autobytel; Management consultants; Audit Bureau of Circulation	Publications ranking universities and professional schools; Career counsellors; HR consultants
Aggregators and distributors	Provide low-cost matching and other value added services for suppliers and customers through expertise and economies of scale	Banks; Insurance companies; Mutual funds; Venture capital; Private equity funds	Trading companies; Mass retailers	Universities; Professional training institutions; Labor unions
Transaction facilitators	Provide a platform for exchange of information, goods and services, provide support functions for consummating transactions	Stock, Bond, and Futures exchanges; Brokerage houses	eBay; Commodities exchanges; Credit card issuers; PayPal	Executive recruiters; Job announcement websites
Adjudicators	Resolve disputes regarding law and private contracts	Courts and arbitrators; Bankruptcy specialists	Courts and arbitrators	Courts and arbitrators; Union arbitration specialists
Regulators and other public institutions	Create the appropriate regulatory and policy framework, and enforce it	SEC; FASB; NASD	FDA; EPA; Consumer Product Safety Commission; FCC; FTC; FAA	OSHA; Equal Employment Opportunity Commission; Unemployment Insurance Agencies

Source: Khanna, and Krishna Palepu (with R. Bullock) 2010.

3.1. The State of Education in India

India has the world's largest school-aged population[10] of ~370 million (Population Pyramid 2022). Unfortunately, only about 260 million kids are in school (British Council 2019). In 2020, the higher secondary enrolment ratio in India was 52 percent (Government of India 2020e), compared with 88 percent in China and 99 percent in the US (World DataBank 2022). The quality of school education is also poor and appears even to be deteriorating by some measures. A recent survey of over 20,000 government school students found that the proportion of Grade 3 students who can read Grade 1 text and recognize double-digit numbers decreased from 41 percent and 75 percent in 2014 to 24 percent and 60 percent in 2020 (ASER Centre 2021).

India also lags on tertiary education (TE) enrollments.[11] Its TE enrollment ratio was 29.4 percent in 2020, versus China's 58.4 percent, EU's 73 percent, and USA's 87 percent (World DataBank 2022). India's education policy targets reaching a ratio of 50 percent by 2035 (Government of India 2020e).

In 2019, 38.5 million students (Government of India 2020e) were enrolled in higher education studies. Of these, 30.6 million are enrolled in undergraduate programs. Around 25 percent of undergraduates are enrolled in science-based programs; including 4.7 million in B.Sc., 2.1 million in BTech, 1.5 million in engineering (Government of India 2020e), and 1.3 million in medical sciences.[12] Of the 6.7 million students who complete their undergraduate degree yearly (Government of India 2020e), 12.5 percent receive engineering and tech degrees (Government of India 2020e; University Grants Commission 2022).[13]

Besides enrollment, the scarcity of high-quality science-based undergraduate programs is another limitation of the current tertiary education system. Over 2.2 million students (Blume Venture Capital 2022) sit for the IIT entrance exams for 16,000 seats, equating to an acceptance ratio of 0.72 percent (Blume Venture Capital 2022). The effective acceptance ratio plummets to 0.3 percent if one accounts for the reservation of over 60 percent of seats for students from backward classes and economically weaker backgrounds. The reservations are warranted as a matter of attempting to level the playing field, but they come at the cost of short-run reduction of scarce seats for currently prepared-talent that might otherwise have been accommodated. This is, of course, a conundrum

10. Children between the ages of 5 and 19 years.

11. Tertiary education refers to all higher education after 12 years of schooling.

12. Medical sciences include nursing, pharmacy, pathology, physiotherapy, homeopathy, and Ayurveda.

13. While the Ministry of Education includes dairy technology, urban planning and transportation planning in its definition of "Engineering & Technology," students receiving an undergraduate degree in these courses represent less than 0.5 percent of all graduates. Engineering graduates account for ~90 percent, while IT and architecture account for 5 percent and 1.7 percent, respectively.

common to all societies, not just India, as the Harvard historian and China scholar, Michael Szonyi, and I explore in a recent co-edited volume, Making Meritocracy (Khanna and Szonyi 2022).

In comparison to the selection rates of elite Indian institutions, top-quality undergraduate engineering programs at US universities such as Stanford, Cornell, MIT, and Princeton, which attract global talent, have acceptance rates of between 5 percent and 10 percent. Consequently, many high-caliber students in India are forced to settle for second-rung colleges or go to foreign educational institutes. The number of students attending overseas universities increased from 56,000 in 1999 to 589,000 in 2019 (Blume Venture Capital 2022). While ed-tech companies and other open-source digital resources are enabling access to top-quality resources online, the absence of adequate high-quality physical educational institutions is a systemic void.

As the average STEM student receives a low-quality education, they are not readily employable after graduation. The educational system's emphasis on rote learning deprives students of sufficient practical learning opportunities. There is little interaction between academia and business; consequently, students are offered few opportunities to understand how science and technology can be applied in real-world situations. By the time students reach higher education levels, they lack the creativity, critical thinking skills, and open-mindedness required to become successful innovators and entrepreneurs (Government of India 2020b). Furthermore, Indian educational institutes provide little training on soft skills like communication and negotiation, among others, a disadvantage that persists over time. Indian entrepreneurs tend to under-network, possibly because they lack the necessary social skills (Dimitriadis and Koning 2021). Entrepreneurial education, including training on spotting trends, evaluating product-market fit, and so on, represents another gap in the education ecosystem.

Given the inadequacies of the education system, the findings of a 2019 Aspiring Minds study pointing to the unemployability of graduates should come as no surprise. The study found that less than 20 percent of engineering graduates are employable for software jobs, less than 8 percent for core engineering jobs, and only 4 percent for core IT product jobs (see Table 4) (Statista 2019a). The founder of one of India's largest IT services companies, Infosys, commented, "Engineering colleges in India are churning out only 25 percent quality engineers and nearly 80–85 percent of youngsters are not suitably trained for any job (India Today Web Desk 2021)." India is currently short of 500,000 workers in tech. By 2026, this gap is estimated to widen to 1.4 – 1.9 million workers (Malik 2022). Deficits are particularly pronounced in new-age digital skills like AI, big data analytics, the Internet of things, and cloud computing, where there is a current shortage of 140,000 workers, up from 62,000 in 2018 (Malik 2022).

Not many students continue education beyond the undergraduate level. Of every 100 undergraduates, 23 receive a graduate degree, and 0.6 a Ph.D. degree

(Government of India 2020a). India has half the number of graduating doctoral students compared to China and the US (Aggarwal 2018). These figures are partly representative of an inadequate number of higher education programs. A 2019–20 report found that only 35 percent of Indian higher education institutions run post-graduate level programs, and only 2.7 percent, Ph.D. programs (Government of India 2020a). Of the 200,000 students enrolled in Ph.D. programs, around half go into engineering, technology, and science-based programs, showing clear interest in these fields (Government of India 2020a).

TABLE 4. Employability of Engineering Graduates in India

Particulars	*2020 (%)*
Employability of engineering graduates in India – by job role	
IT Engineers:	
Associate – ITeS operations (hardware and networking)	36
Software engineer – IT services	16
Startup ready – IT services	4
Software engineer – IT product	3
Chemical design engineer	8
Mechanical design engineer	7
Electronics design engineer	7
Design engineer – non-IT	7
Electrical design engineer	6
Civil design engineer	5

Source: All India Survey on Higher Education 2019-20 (Government of India 2020a), "National Employability Report".

As low numbers of students receive graduate degrees, academic research in India lags behind that in other countries. The ecosystem for research as a career path is largely missing, with insufficient rewards and recognition for those who enter the field. Indian higher education institutions also underspend on research, spending US $3 billion on average, versus US $24 billion and US $62 billion by institutes in China and the US, respectively. As of 2018, India had 156 researchers per million citizens, versus 4,205 and 1,089 in the US and China, respectively, and a global average of 1,500 (UNESCO Institute for Statistics 2022). Between 1996 and 2020, India ranked seventh globally in the number of science and tech research publications, with 2 million published articles, while the US and China, the leading countries, published 14 million and 7 million articles, respectively (Scimago Journal & Country Rank 2020). By 2018, India's cumulative contribution to global scientific research was merely 5 percent, compared with China's 21 percent and the US's 17 percent (National

TABLE 5. R&D Spend as a percent of GDP, Patents, Research and International Co-authorship

Year	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Percentage of GDP spent on R&D								
United States	2.8	2.7	2.7	2.7	2.7	2.8	2.8	2.8
China	1.8	1.9	2.0	2.0	2.1	2.1	2.1	2.1
India	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Number of patent applications to the US Patent and Trademarks Office								
China	10,545	13,273	15,093	18,040	21,386	N.A.	N.A.	N.A.
India	4,548	5,663	6,600	7,127	7,976	N.A.	N.A.	N.A.
Percentage of patents granted by the US Patent and Trademarks Office								
China	1.5	1.9	2.2	2.4	2.8	N.A.	N.A.	N.A.
India	0.5	0.6	0.8	0.9	1.0	N.A.	N.A.	N.A.
Percentage of patents granted by the Indian Patent Office								
Indians	17.0	16.0	17.4	15.0	11.4	14.5	13.4	14.8
Foreigners	83.0	84.0	82.6	85.0	88.6	85.5	86.6	85.2
Number and percent of total, science & engineering articles published· by country								
United States								4,22,808 (17%)
China								5,28,263 (21%)
India								1,35,788 (5%)
Percentage of papers with international co-authorship (2019)								
United States								40.9
China								23.0
India								18.9

Source: Research and Development Statistics 2019–20 (Ministry of Science & Technology, Government of India 2020d), World Bank, Economics of Industrial Research & Innovation–European Commission, National Science Foundation, UNESCO Science Report 2021.

Science Foundation 2019). A survey of highly cited papers by country showed India lagged China by a factor of six (Aggarwal 2018).

3.2. Lack of Funding for Scientific Research and Entrepreneurship

A bedrock of independent, inquiry-based research is a sine qua non for scientific progress, innovation, and ultimately long-term growth. The US research ecosystem is fueled by government spending. Over decades, about a third of US patents rely on federally funded research, and these tend to be the patents that are more cited, and more commercially valuable (Fleming et al. 2019).

India's persistent underfunding of basic research represents perhaps the most significant headwind to science-based entrepreneurship. India spends less than 1 percent of GDP on R&D, a ratio that has, in fact, been declining over time (see Table 5). In contrast, Germany allocates nearly 3 percent of GDP to R&D, the US spends 2.5 percent, and China, more than 2 percent. Global leaders like Israel and South Korea dedicate over 4 percent of GDP to R&D, while advanced European economies, between 3 percent and 4 percent. Other BRICS countries also spend more on R&D as a percent of GDP. Even after adjusting for PPP, the US spends ten times more, and China seven times more than India, on R&D (see Table 6). Further, funding models for R&D are not always linked to performance metrics such as research publications, patents, or number of researchers.

TABLE 6. R&D Spend Percentage, by Segment of the Economy and PPP Adjusted Spending, US $ billion

Country	*Government (%)*	*Business (%)*	*Universities (%)*	*Private Non-profit (%)*	*Total Spend (US$ billion)*
US	11	72	13	4	476
China	16	77	7	N.A.	346
India	56	37	6	N.A.	47

Source: UNESCO Institute for Statistics 2022.

Low R&D spending limits India's technological advancements. Patent filings, for example, are one rough indicator of a country's technological progress. In 2002, both China and India filed close to 800 patent applications at the US Patent and Trademark Office (USPTO), of which 390 were granted to China, and 267 to India. In 2015, China filed over 21,300 applications while India filed less than 8,000 (U.S. Patent and Trademark Office 2022a). From 2002 to 2015, the share of foreign patents issued by the USPTO to China increased from 0.4 percent to 5.3 percent, while India's share increased only from 0.3 percent to 2 percent (U.S. Patent and Trademark Office 2022b). Even within India, only 15 percent of patents issued by the Indian patent office accrue

to Indians and Indian companies, while the remaining are issued to foreign nationals and corporations (see Table 5). Streamlining of patent processes, and greater education of entrepreneurs regarding intellectual property rights (IPR) can help. The government has also experimented with subsidizing patent fees for startups and providing free counselling to navigate the filing possibilities (Press Information Bureau, Government of India 2023). These are sensible steps. Yet, despite improvements, India's patenting in 2020 is still roughly only a tenth that of the US, and lags China even further (Sanyal and Arora 2022). Given the general paucity of funds, it is unsurprising that ideas emanating from untested science find it difficult to attract funding. Science and deep-tech startups typically have a limited sense of commercial viability when they apply for funding. Investments in such ventures present a higher risk of failure than in more traditional segments. Furthermore, it can often be challenging for VC executives to accurately assess the research or technology proposed by such startups. VC firms also find it challenging to match entrepreneurs' needs for capital over long-term horizons, as they operate under finite time frames for returning capital to their own investors.

These factors make it imperative for society—including but not limited to the government—to find ways to fund science-based startups that emanate from novel science, initially by using funds of the sort not available through VCs for de-risking this science. The Biotechnology Industry Research Assistance Council (BIRAC) under the Department of Biotechnology of the Ministry of Science and Technology represents a small but encouraging start. BIRAC has funded nearly 500 med-tech companies, helping bring more than 50 products to the market (Rajan et al. 2021). On the whole, however, government spending on R&D remains grossly insufficient (see Table 5). One reason for this is the belief that R&D spending is a 'luxury that India cannot afford (Kumar 2019).' With a GDP per capita of US $6,500 in PPP terms (World DataBank 2022), India is still a relatively poor country. There is enormous pressure to spend constrained resources on building critical infrastructure rather than on categories viewed as non-essential, including research. The concentration of government spending on R&D is also a problem. More than 50 percent of government R&D funds are allocated to two agencies, the Defence Research & Development Organization (DRDO) and the Department of Space (DOS) (Government of India 2020d). Other agencies, such as the Indian Council for Medical Research and the Ministry of Environment, Forest and Climate Change, receive little funding, limiting their research output.

Although the private sector's contribution to total R&D spend is increasing, from 25 percent in 1991 to 37 percent in 2018, it lags behind other countries. In the US and Germany, the share of private sector funding of R&D is ~70 percent (UNESCO Institute for Statistics 2022). While profit as a percent of GDP at Indian firms has increased from 0.8 percent in 2003 to 2.2 percent in 2018 (Statista 2019b), there has not been a proportional increase in R&D

investment. In 2020-21, Indian listed companies spent 0.9 percent (Oberoi 2020) of revenues on R&D, versus S&P 500 companies, which on average spent 4 percent. Only one Indian company, Tata Motors, featured in the list of top 100 global spenders on R&D, while the list featured 38 companies from the US, 14 from Japan, 12 from Germany, and 8 from China. Average R&D spend across the top 100 spenders was a whopping 7.5 percent of total revenue. Of the top 2,500 spenders on R&D, only 29 companies were Indian. Of these, 21 operate in just three sectors: pharmaceuticals, automobiles, and software. Even within the pharmaceutical industry, an area of strength for India, firms spend only 8 percent of revenues (India Brand Equity Foundation 2021) on R&D, while US firms spend 21 percent on average (Statista 2021; Drug Discovery & Development 2022).

Private sector spending on R&D has languished for many reasons. One reason is the scarcity of basic publicly-funded research that the private sector can build upon. Indeed, the roots of many commercially used products can be traced back to research funded by universities or the government. In the 1970s, the US Department of Defense (DoD) funded research to develop the 'Global Positioning System' (GPS), a satellite navigation system. This technology was later made available for public use and is now an invaluable facet of everyday consumer products such as cars and phones (NASA 2012; Comen and Suneson 2019). The Internet was developed by the Advanced Research Projects Agency, a DoD-funded computer science research project that aimed to allow scientists and researchers to share information, knowledge, and findings (Free Code Camp 2020). The Human Genome Project, publicly funded by the US Department of Energy and US National Institutes of Health, brought together scientists from across the world (Office of Science and Office of Biological and Environmental Research, US Department of Energy 2019) to discover the complete set of human genes and the sequence of DNA bases in the human genome. The findings have transformed biology (Office of Science and Office of Biological and Environmental Research, US Department of Energy 2019). Some of the most innovative products today, including the reusable rocket system developed by SpaceX, LED bulbs, the Apple iPad, and Amazon's Kindle, are the results of R&D investment by private companies (Ryan 2019) in technologies that represent the de-risking of publicly funded science. In the US, this conceptual framework—the idea that the fruits of publicly-funded research are equally accessible to all and that individuals can establish property rights on the incremental advancements atop these—was facilitated by the Bayh-Dole Act of 1980 (Latker 2000).[14] This symbiosis of individual entrepreneurial agency building upon publicly-funded science is largely missing in India.

14. The Bayh-Dole Act permits non-profit organizations and small business firm contractors to retain ownership of inventions developed through public funding. It also authorizes federal agencies to grant exclusive licenses for inventions owned by the federal government to others.

Related to the difficulty of accessing novel science is the observation that Indian firms are often focused on low-cost imitations of western ideas. Few Indian companies aim to grow through investment in research and innovation. It is also uncommon for large corporates to invest in ideas stemming from other smaller private research entities and individuals, as happens frequently in the US. Amazon, for example, has established two funds to do this. The US $1 billion Amazon Industrial Innovation Fund is dedicated to logistics and supply chain investments (Savitz 2022), and the US $200 million Alexa Fund is dedicated to investments in voice technology innovation (Amazon 2022). Such funds play an essential role in developing the research ecosystem. In this regard, the government's decision to allow firms to count R&D grants to government-funded incubators and research institutions, as part of the mandatory 2 percent of revenue corporate social responsibility target is a positive step (Times News Network 2019). Leading Indian research institutions are reporting an increase in sponsorship. The sponsored research of IIT-Madras has seen steady growth, with funding increasing from Rs 108 crores in 2014–15 (Gohain and Rao 2019) to Rs 590 crores in 2020–21 (Indian Institute of Technology Madras 2021).

Increased Foreign Direct Investment (FDI) in R&D, currently at 0.13 percent of total FDI, also can boost R&D activity in India (Gupta 2022). FDI brings in not only funds but also training and expertise that can help propel India into a world-class research and innovation hub. There have been many examples of foreign partners accelerating the development of innovations. The rapid development of the COVID-19 vaccine is one example. Incentivizing foreign firms to establish global R&D centers in India is one proposal to boost FDI in research. Some firms like CISCO and General Electric have already done this. FDI in R&D can be boosted by fast-tracking IP granting procedures, setting up specialized courts for IP disputes, and simplifying regulatory compliance requirements.

3.3. Lack of Collaboration in Research

Innovative solutions to large-scale global problems typically require inter-disciplinary thinking, and therefore collaboration amongst researchers is crucial. A 2018 OECD report envisioned that the future of scientific knowledge will come from collaboration: "Innovation springs not from individuals thinking and working alone, but through cooperation and collaboration with others to draw on existing knowledge to create new knowledge (Jones 2009)." A fallout of the explosive growth in our cumulative amount of knowledge is increased specialization. For example, biology today has numerous branches with increasingly narrow specializations within each branch. As research moves further, the resulting silos may limit the acquisition of the broad knowledge and collaboration required to achieve transformational change. Attempts to tackle complex real-world problems from narrow fields of vision will likely result in fragmented incomplete solutions.

In India, the lack of collaboration within academia and between academia and industry presents a gap in the innovation ecosystem.

3.3.1. Lack of Collaboration Within Research

Research in India is silo-ed and fragmented. Few Indian institutes have multi-disciplinary research platforms. An example of what I have in mind, parochial to my backyard, is the Harvard University Centre for the Environment (HUCE), embracing an interdisciplinary approach to promote research and education on the environment. The center connects students and faculty at Harvard University from diverse fields, including chemistry, earth, and planetary sciences, engineering and applied sciences, history, biology, public health and medicine, government, business, economics, religion, literature, and law. We have long known that substantial scientific advance comes through what is perhaps best described as a combinatorial advancement process, mixing and matching bits and pieces of scientific and humanistic insight (Uzzi et al. 2013). By connecting scholars and practitioners from different disciplines—transcending conventional boundaries of pure science, social science and humanities—the center provides aspiring researchers, policymakers, and corporate leaders a comprehensive interdisciplinary platform for research and education (Harvard University Center for the Environment 2022). It is worth emphasizing an emerging consensus that pure science (and engineering) is more effective in addressing human needs when its insights are juxtaposed paired with those from the humanities.

3.3.2. Lack of International Collaboration in Research

India lags behind other countries on international research collaboration. In 2019, 19 percent of India's research output stemmed from international collaboration, versus 23 percent in China, and 41 percent in the US (see Table 5) (UNESCO 2021).

International collaboration in research is important as it enables access to global talent pools, and larger amounts of data and infrastructural facilities, thereby improving output. It also offers many personal benefits for researchers. It typically leads to greater recognition, as papers with multiple authors are more likely to be cited (Adams 2012). It enables skill development through mutual learning, and opens up opportunities for mobility, leading to personal and professional growth and satisfaction (Guthrie et al. 2017. These factors, in turn, make research a more attractive career path for young people.

There are many examples of successful international scientific collaborations dating back several decades. In the 1970s, the International Rice Research Institute (IRRI), which aims to enhance food security using research in agricultural science (CGIAR 2022), produced one of the first high-yielding rice varieties that helped stave off mass famine in Asia. Another well-known

example is the effort that led to the International Space Station (ISS) project, a collaboration between 16 nations to build and operate a world-class research center in space. A more recent international collaboration, in which India is largely absent, is the Earth Biogenome Project, that aims to sequence genomes of the Earth's bio-diversity over a period of 10 years. Many other international collaborations continue to solve some of the world's biggest problems, such as AIDS, polio, and environmental degradation, among others (Clinton White House Archives 2022).

3.3.3. Lack of Collaboration between Research and Industry

Across the world, collaboration between industry and academia has been the critical fuel for innovation and technological progress. Industry represents the best option to translate the gains in scientific knowledge into practical applications in the form of products and services. Regions that have been able to structure collaboration into networks, such as California's Silicon Valley and Cambridge's Bio Cluster, have sustained long-term success. Research finds that the higher level of informal and formal networks between firms and between firms and academic and other research organizations has been instrumental in Silicon Valley's success.

In India, collaboration between industry and research was considered critical for innovation and success.[15] But in reality, there was a gap in collaboration, stemming from a divergence in how stakeholders view each other's roles. Researchers view their role as building foundational knowledge and tend not to focus on the translation of their research to serve practice. Industry tends to treat government-funded research institutions as part of a larger bureaucracy, which limits the free flow of information between the two and slows any iterative give-and-take and the resultant refinement of relevant scientific ideas. Private sector firms are also reluctant to invest time and resources to bring academic research to a market-ready state. This mistrust of mutual capacity and intent has resulted in limited networks of interaction and communication. In some cases, collaboration is hampered by lack of clear policies. For instance, not all institutes of higher education have clear policies for faculty entrepreneurship.

Given the extensive co-location of research institutions and industry, there is enormous scope to collaborate. The National Chemical Laboratory (NCL) is an example of a collaboration that has worked well. Under Dr Raghunath Mashelkar's leadership in the early 1990s, the NCL, one of the 37 labs of the

15. According to a recent study, more than 50 percent of the deep-tech startups surveyed believed that collaboration with academia was important in the quest for patentable technologies. See NASSCOM and Zinnov. August 2022. "India's DeepTech Startups Poised for Impact," https://community.nasscom.in/communities/productstartups/indias-deeptech-start-ups-poised-impact, accessed March 2023.

Council for Scientific and Industrial Research (CSIR)[16] across the country, collaborated extensively with firms like General Electric to develop and patent polymers. Mashelkar believed that research organizations should focus on patent creation as 'patents are wealth creators.' His focus on 'patent, publish and prosper' resulted in NCL owning 88 percent of all foreign patents granted in 1994 across all CSIR's labs. Upon taking over as director-general of CSIR, Mashelkar endeavored to inculcate this mindset across all labs (Choudhury and Khanna 2020). Such examples of collaboration, however, remain the exception rather than the norm.

3.3.4. Insufficiency of Business Incubators

Business incubators are a relatively nascent phenomenon in India. There are ~0.4 incubators per million citizens, compared with 4.5 and 2.1 incubators per million citizens in the US and China, respectively (NASSCOM 2020). Incubators are concentrated in a few elite academic institutions (IITs, IIMs) and select States such as Tamil Nadu, Karnataka, Maharashtra, and Delhi, and not widely accessible to aspiring entrepreneurs (Rajan et al. 2021).

There is also scope to improve the quality of incubators. Indian incubators are criticized for being primarily providers of physical infrastructure rather than technical know-how, domain expertise, and relevant commercialization advice. In a 2019 NASSCOM survey, about 60 percent of startup respondents[17] said that Indian incubators underperform vis-à-vis their global peers, half said that they could find alternative investors more capable of enabling genuine value creation, and a third said that the Indian incubator model is outdated (NASSCOM 2020). India is yet to witness a startup from an incubator achieve unicorn status (NASSCOM 2020). A study of Chilean incubators found that providing basic services like funding and infrastructure does not tangibly impact new venture performance but training and mentorship can significantly help (Gonzalez-Uribe and Leatherbee 2018). With the advent of co-working spaces and other peripheral infrastructure, incubators must offer differentiated services. It is essential to design and track KPIs to assess the progress and impact of incubators. Without such frameworks, inefficient incubators may continue to operate indefinitely without generating adequate value, diminishing impact, and experience (Rajan et al. 2021).

Some academic institutions have established successful incubators. The Indian Institute of Madras's Incubation Cell (IIMIC), for example, has incubated 233 startups, which have raised over US $296 million, filed for 100+ patents,

16. CSIR is a network of labs, outreach centers, and innovation complexes under the Ministry of Science & Technology, focusing on areas such as environment, farm, food, drinking water, housing, and energy.

17. This NASSCOM survey was part of the report 'Startup Catalysts - Incubators and Accelerators, 2020'. Participants n=24.

and created over 4,000 jobs (Indian Institute of Technology Madras 2022). One of the cell's most successful ventures is Ather Energy, a firm that pioneered the manufacturing of smart electric scooters and the setting up of electric vehicle charging infrastructure in India. A key reason for the cell's success is its strategic location within India's first Science and Technology Research Park, designed on the lines of the Stanford Research Park. The Park houses over 70 research organizations across 17 sectors, and 200 labs and testing facilities. It has generated 1,300 patents.

4. Current Public Policy Initiatives

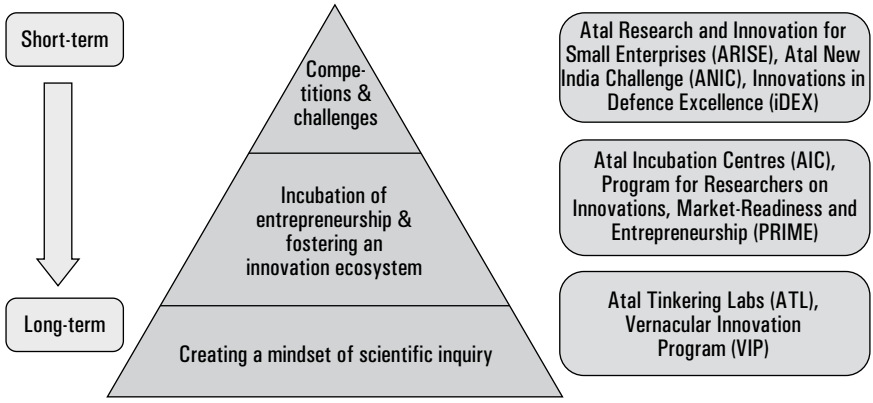
Institutional voids bedeviling science-based entrepreneurship cannot be mandated away through deregulation and liberalization; it takes both significant time and expertise and, frankly, institutional entrepreneurship here itself, to eliminate these voids or ameliorate their effects. In the following section, I elaborate on distinct policy initiatives introduced by the government to boost innovation and entrepreneurship in the science and deep-tech sector, and how these initiatives are bridging the existing institutional voids in this space.

The first, the Atal Innovation Mission (AIM), set up under the NITI Aayog, has demonstrated considerable traction in the innovation ecosystem through its programs. The second, the Science and Technology Clusters project under the Office of the Principal Scientific Advisor (PSA), is described below but it is still too early to offer an assessment. Another program at the confluence of these two policy initiatives is the AIM Program for Researchers in Innovation, Market Readiness, and Entrepreneurship (PRIME), which aims specifically to promote entrepreneurship in science.

4.1. Atal Innovation Mission

The AIM was launched in 2016 to provide an umbrella under which a wide variety of programs to catalyze the innovation ecosystem could find an institutional home. The report resulted from an approximately year-long consultative process in 2015 launched by the Government of India under NITI Aayog auspices that I had the privilege of chairing. The underlying conceptual framework sought to suggest ways to ameliorate the effects of institutional voids over the short, medium, and longer-term (see Figure 1). Table 7 presents a summary of how programs of the AIM (Atal Tinkering Labs and Atal Incubation Centres) address broad categories of relevant voids. I have also made some back of the envelope calculations on the value generated at the ATLs and AICs between 2016 and 2021 (see Table 8).

FIGURE 1. Programs under the Atal Innovation Mission



Source: Report of the Expert Committee on Innovation and Entrepreneurship, NITI Aayog, August 2015.

TABLE 7. Current Initiatives Bridging Institutional Voids

Role	*ATL*	*AIC*	*PRIME*
Transaction Facilitator	–	Bring together providers and users of risk capital	Bring together investors to enable participants to raise money and create awareness about opportunities in science and technology
Credibility Enhancer	–	Validate entrepreneurial projects that have passed muster in typically a 3–6-month period	Validate commercial potential of scientific research, new technologies, products, and services
Information Analyzer	Identify high school students with a science interest and aptitude	Convert tacit information about quality of entrepreneurial teams and/or their ideas to make these available to transaction partners	
Aggregator	Facilitate distribution of training materials for high school science teachers, Aggregate mentoring services (complement to efforts of teachers) associated with formal organizations	Provide a means to aggregate pools of capital so as to facilitate access to these for decentralized entrepreneurs	Aggregate content on a public YouTube channel, and the PRIME playbook which is used for broader dissemination within the community

Source: The author.

TABLE 8. Back-of-the-envelope Calculation on Value Generated under AIM, 2016–21, Rs in crores

Particulars	*Amount (Rs crores)*
AIM Expenditures	1,511
Of which, investment in startups	252
AIM Benefits	
Benefit (A): Value Created by Startups and Incubators	
Benefit (B): Value Created by Atal Tinkering Labs	
Elaborating Benefit (A):	
Mark-to-Market Value based on 2,729 startups' capital raises	6,835
Money raised (Rs 1367 crores), assume 20% dilution on average	
(excludes social spillovers from companies' 467 patents)	
(Pessimistic) Accounting value of 14,556 new jobs @Rs 30,000 /month salary	524/year
(Less Pessimistic) Capitalized value of new jobs	7,486
(capitalizing Rs 524 crores/year at 7% social cost of capital)	
AICs capital raise in matching funds	58
Valuation of infrastructure	
Benefit (A) Total	
Conservative: ~30x return	7,417
Less Conservative: >50x return	14,379
Elaborating Benefit (B):	
75 lakh students sensitized to ideas of innovation and entrepreneurship	
Conservative value: Accounting cost of such exposure	750
(assuming it costs students Rs 1000 for an equivalent course)	
Less Conservative: Capitalized value of such exposure	10,714
Rs 750 crores at 7 percent social cost of capital	
Student 'mindset' earns perpetuity value of incremental earnings attributable to creativity	
Total Benefits (A+B)	
Conservative: (5x return)	8,167
Less Conservative: (17x return)	25,093

Source: Author computations and Dr Chintan Vaishnav, Atal Innovation Mission.

4.1.1. Atal Tinkering Labs

The Atal Tinkering Labs (ATL) project is one such longer-term initiative that seeks to bridge institutional voids by aggregating and providing educational resources, equipment and mentorship services to school students.

The program entails the setting up of physical laboratories in schools, equipped with scientific kits and apparatus for students between the sixth and twelfth grades. The hope is that the opportunity to "tinker," and learn by doing, will sow the seeds of a scientific mindset and an entrepreneurial spirit amongst children from an early age. The program's vision is to create one million innovators with complex problem solving, critical thinking, adaptative learning, and computational skills.

The AIM provides a grant of up to Rs 20 lakhs over five years for the setting up of each ATL. Schools must apply to be admitted into the program—de minimis physical facilities are needed as is the identification of a school teacher who is the ATL in-charge—and selected schools then receive the grant. Up to Rs 10 lakhs is to be spent on capital expenditures, including machinery, equipment, and tools, and the remaining Rs 10 lakhs may be used for operational and maintenance expenses. The AIM has a mandate to fund 10,000 ATLs in the first phase. As of May 2022, it has funded 9,600 spaces in 34 States and Union Territories. These have been rolled out in implementation waves over recent years, with attention to locating ATLs across States with varying levels of economic and social development, and across some aspects of the urban-rural divide. The labs have been equitably distributed across the country, with 53 percent of the labs in States with a GDP per capita above the national median, and 47 percent in States with a GDP per capita below the median. The AIM has also given particular importance to States typically ignored such as Jammu & Kashmir, where it plans to set up 1,000 labs, and the north-eastern States, some of which currently have the highest number of labs per million residents. Further, more than 70 percent of ATLs have been set up at government schools. The labs have engaged over 7.5 million students who have created over 2.1 lakh projects (Atal Innovation Mission 2022e).

Through various programs, the ATLs offer students an array of opportunities. ATL schools are encouraged to engage with stakeholders in their communities to better understand and address their challenges. ATLs also leverage their communities through the Mentors of Change (MoC) initiative. Mentors are selected and trained volunteers who support the ATL-in-charge teacher by helping students with technical know-how and advice on commercial aspects of innovation; some also offer internships in the organizations with which they are affiliated. The MoC initiative has connected more than 5,100 mentors with over 4,600 schools. While this program is a step in the right direction, its scale is still small. Today, less than half of existing ATLs have even one mentor and the per-ATL mentor count is very low.

The ATLs also address voids by serving as credibility enhancers to students who participate in its events and challenges. These include the 'Student Innovator Program' (SIP)[18] and the 'Student Entrepreneurship Program' (SEP).[19] Winners of these challenges are offered opportunities such as internships and access to international programs[20] and additional resources and mentorship.

To motivate participants, the AIM regularly celebrates high-performing ATL participants through initiatives like the Exemplary Teachers of Change[21] and the ATL of the Month initiative.[22] The AIM also organizes a mentor roundtable bi-annually, where exemplary mentors are invited to spend time with senior officials from the NITI Aayog (Atal Innovation Mission 2022f). While such recognition is helpful, a lot more can be done. Teachers at ATL schools are typically on low salaries with few opportunities and platforms for recognition. Non-financial incentives including more opportunities to travel, learn, and connect with a national and international community could motivate them. Likewise, small financial incentives for achieving key outcomes could also incentivize better performance.

Notwithstanding initial successes, the program faces several challenges. For starters, there is a wide gap between the pre-existing educational level of a vast majority of students at ATL schools and the skills required to "tinker" at the labs. Bridging this gap requires cultural change, and will take time. The quality of teacher and mentor engagement across ATLs also varies significantly. Given the high work-loads for teachers at schools, there is often little incentive for them to put in the additional work required for students to tinker and innovate effectively. Further, the infrastructural pre-requisites for setting up labs and the single language of instruction (English) curtail the reach of the program. Many schools have also reported the compliance procedures to be cumbersome. Another limitation of the ATLs is the lack of outreach to a critical stakeholder in the child's innovation journey, the parents. Finally, an obvious challenge is that the AIM cuts off funding to ATLs five years after their initiation. While the AIM encourages labs to become financially self-sufficient through self-funding and corporate partnerships, this approach will inevitably lead to some labs being discontinued, especially in rural areas, possibly stymieing the momentum of the program.

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18. A program in collaboration with AICs to train students on business and entrepreneurial skills.

19. A 10-month program where top teams from the SIP work with corporate and industrial partners and receive further mentorship and training on product design and commercialization.

20. An example is the Indo-Singapore Innovation Festival-Inspreneur, organized by the High Commission of India in Singapore. In 2018, 30 top-performing ATL teams were invited to present their innovations to the Prime Minister of Singapore, Lee Hsien Loong, and the Prime Minister of India, Narendra Modi.

21. An initiative to recognize high-performing teachers in charge of the tinkering labs.

22. An initiative to recognize students and teachers at high-performing labs by means of an award.

The AIM is attempting to address some of these challenges. To simplify compliance and improve engagement, the AIM is creating regional clusters that will decentralize monitoring. To improve accessibility, the ATL is piloting mobile and virtual ATLs, and designing resources in vernacular languages through the Vernacular Innovation Program (VIP). Further, the AIM is also collaborating with the Ministry of Education (MoE), Central Board of Secondary Education (CBSE),[23] National Council of Educational Research and Training (NCERT),[24] and the State governments, to integrate the ATL pedagogy into the school curriculum. This initiative should help scale the program to 50,000 schools, the newly adopted AIM target for its ATL program.

4.1.2. Atal Incubation Centres

Through the Atal Incubation Centres (AIC) program, the AIM aims to build an ecosystem of business incubators where entrepreneurs can gain access to a variety of facilities, including physical infrastructure, training and education, and access to key stakeholders including investors (AIC seed funding, and also a network of venture capitalists, corporate funding, family offices), other innovators, and mentors.

The AICs act as transaction facilitators by bringing together providers and users of risk capital. They serve as aggregators by consolidating pools of capital and facilitating entrepreneurs' access to these pools. Finally, they are information analyzers by converting and making available to possible partners otherwise-tacit information about the quality of entrepreneurial teams and their ideas.

The AIM provides a grant of up to Rs 10 crores over five years for the setting up of an AIC (Atal Innovation Mission 2022d) or to support investments at 'Established Incubation Centers' (EICs) (Atal Innovation Mission 2022d).[25] Subsequent tranches of the grant are conditional on meeting minimum performance metrics. The AIM has also raised Rs 58 crores in matching contributions from participating institutions for infrastructural investment at the AICs.

Academic institutions, research labs, and corporates are eligible to apply for an AIC. The applicant institution is responsible for hiring a full time-CEO and supporting team within 30 days of receiving the grant. The AIM requires that the CEO has experience in entrepreneurship, fund raising, technology, or incubation. The CEO of one of the bio-incubators in Bangalore, for example, has a PhD in brain research from a university in Germany, and postdoctoral

23. A national level educational governing body set up to raise the standard of education in India.

24. A government body that conducts research, and prepares and publishes materials for school education.

25. EICs are existing incubators which have already been in operation for a minimum of three years.

training from the University of California, San Francisco, and has completed a biotech management program for executives from the Wharton School. He previously worked at a biotech consulting company and has also been an adviser to many biotech firms in the US.

An example worth highlighting is Phool.co, a startup that recycles floral waste into incense sticks and oils. This venture received a seed grant of Rs 30 lakhs from the Indian Institute of Information Technology Hyderabad AIC, and raised Rs 60 crores in its Series A in May 2022 from other investors (Tripathi 2022).[26] Another is Bugworks, a clinical-stage bio-pharmaceutical company which aims to develop affordable, accessible, novel therapies to combat anti-microbial resistance and cancer. It was set up in 2014 and incubated at an EIC, the Centre for Cellular and Molecular Platforms (C-CAMP). C-CAMP is a bio-incubator set up by the Department of Biotechnology and receives support from the AIM. Bugworks is also a part of the Combating Antibiotics-Resistant Bacteria Accelerator (CARB-X), a non-profit accelerator at Boston University, where it raised Rs 20 crores in 2017 (CARB-X 2022). It raised an additional Rs 135 crores in its Series B in February 2022 (Rekhi 2022).[27]

The AIC program faces several challenges in practice. Many centers have struggled to build market connections, particularly with investors, where the landscape is highly fragmented. Few have successfully scaled manufacturing-based ventures or backed ventures that are able to supply the government. To achieve success, centers need to have clear targets, and progress needs to be monitored.

The AIM is addressing some of these challenges. In collaboration with IIT Delhi, it is piloting a framework of 23-input, process, and output indicators to strengthen evaluation. Some of these indicators include number of startups incubated per year, active network partners, external funding raised, patents filed, and jobs created. The framework classifies incubators based on characteristics such as age and focus areas to measure impact more accurately. For example, for research-focused incubators, the framework places greater emphasis on parameters like patents filed and external funds raised, while for social incubators, it emphasizes job creation. AIM is also creating virtual platforms to connect startups with investors, and other key stakeholders like mentors, manufacturers, and the government. While these are steps in the right direction, significant effort is still required to improve incubator performance. An acid test will be whether underperforming AIM incubators have their support withdrawn if and when they fail to meet pre-specified performance targets.

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26. Investors include Sixth Sense Venture, Indian Angel Network Fund, and actor Alia Bhatt.

27. Investors include Lightrock India, The University of Tokyo Edge Capital (UTEC), Japan, Global Brain Corporation, 3ONE4Capital, Acquipharma Holdings, IM Holdings and Featherlite Group India.

4.1.3. Working with Ministries

In addition to independent initiatives such as the ATLs and AICs, the AIM also engages with several ministries through various programs and competitions. These initiatives are aimed at synergizing the efforts of various ministries in promoting innovation and entrepreneurship in their sectors. For instance, the AIM has launched the Applied Research and Innovation in Small Enterprises (ARISE), Atal New India Challenge (ANIC), and the ed-tech demo day competitions in collaboration with partner ministries (see Table 9). Another collaboration, which falls under the aegis of the Ministry of Defence, is the Defence Innovation Organisation (DIO). The DIO has had significant impact in fostering innovation, entrepreneurship, and self-reliance in the defense sector, in line with the government's Aatmanirbhar Bharat vision.

TABLE 9. Other Initiatives and Programs of the AIM

Program Name	*Description*
Atal Community Innovation Centres (ACICs)	The ACICs are physical centers which aim to promote the benefits of technology-led innovation in the underserved regions of India. These include Tier 2, Tier 3 cities, aspirational districts,* tribal, hilly, and coastal areas. There are currently 12 ACICs in operation, and the AIM gives each center a grant of up to Rs 2.5 crores over five years (Atal Innovation Mission 2022c). Along with the physical infrastructure, the ACICs provide innovators in the centers with mentoring, networking, incubation, and funding support. These centers enable members from the local community to convert grassroots innovation into products and services.
Applied Research and Innovation in Small Enterprises (ARISE)	ARISE is an initiative of AIM in collaboration with partner ministries,# and some organizations including ISRO, launched to promote research and innovation at MSMEs and promote self-reliance. Through this program, partner ministries set out specific problem statements for which MSMEs conduct research and develop products. A grant of up to Rs 50 lakhs is made to winners to develop a prototype. For example, under ARISE 1.0, launched in 2020, the Ministry of Defence invited applications for AI-based predictive models for the maintenance of plant and machinery, and for the development of a modem for high-definition data communication. Similarly, other participating ministries invited applications for projects within their areas. The AIM has approved over Rs 11.6 crores in grants for winners of ARISE 1.0, which will be disbursed over 9–12 months.
Atal New India Challenge (ANIC)	The ANIC is a competition launched by the AIM to promote technology-based innovation in sectors of national importance. ANIC 1.0 was launched in 2018 in partnership with five ministries, Railways, Housing and Urban Affairs, Agriculture, Road Transport and Highways, and Jal Shakti.† The competition had 24 challenge areas and received over 900 applications. Ultimately, the ministries selected 30 innovations from 12 challenge areas to receive grants of up to Rs 1 crore each over 12–18 months. A total amount of Rs 22.85 crores was approved, of which Rs 6.85 crores has been disbursed (Atal Innovation Mission 2022b). ANIC 2.0 was launched in April 2022 with 18 challenges from seven sectors; EV charging infrastructure, smart mobility, AI and machine learning for space applications, medical devices, sanitation, waste management, and smart agriculture (Press Information Bureau, Government of India 2022).

(Table 9 continued)

(Table 9 continued)

Program Name	*Description*
India-Australia Circular Economy (I-ACE) Hackathon	I-ACE is a competition jointly organized by the AIM and the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia. The program seeks to foster innovative solutions in developing a circular economy within the food system value chain. Such international collaborations are an opportunity for Indian startups to learn from the best practices of startups in other regions and to collaborate on research by sharing resources.
AIM-iCrest	iCrest is a program jointly developed by the AIM, Bill and Melinda Gates Foundation and the Wadhwani Foundation. The program is a structured capacity-building effort to enable incubators in India to implement world-class entrepreneurship programs, build credibility, and become financially sustainable. The program uses the best practices from over 200 accelerators and incubators globally to bridge existing gaps at the AICs and EICs (Atal Innovation Mission 2022a).
AIM iLEAP	AIM launched the iLEAP program with Startup Réseau,[‡] with the objective of overcoming two significant bottlenecks startups face: market and investor access. This program provides AIM-backed startups access to Startup Réseau's global network of mentors, and investors. Five verticals of the program are fin-tech, cyber security, med-tech for home-based solutions, climate-tech for fighting air pollution, and audio-tech.
Demo Day for Ed-Tech	Demo Day is a competition organized by the Ministry of Education (MoE) in collaboration with the AIM for companies working on educational solutions for children with special needs. This competition provides a national level platform for companies to showcase latest innovations such as assistive teaching technologies and adaptive equipment. Such programs help innovators and entrepreneurs get exposure to potential customers, mentors and investors.
Agri-Tech Challenge 2021	The Agri-Tech competition is an international collaboration of the AIM with by the UN Capital Development Fund (UNCDF), the Bill and Melinda Gates Foundation, Rabo Foundation, International Fund for Agricultural Development (IFAD), and Bayer. The competition aims at supporting startups that are finding solutions to three large obstacles that small farmers face; low productivity, climate risk and inefficient supply chains. Selected participants receive support in the form of industry and sector linkages, investor connects and financial grants to enable international expansion in Asia and Africa.
AIM Youth Co:Lab India	Youth Co:Lab was co-created by the UNDP Asia Pacific and the Citi Foundation in 2017 and is a program that aims to strengthen youth-led innovation and social entrepreneurship. The AIM launched the Youth Co:Lab program in India. The fourth edition of the event was held in 2021 and focused on identifying and supporting young entrepreneurs across certain themes, including, the circular economy, waste management, sustainable transportation, e-mobility, sustainable tourism, and sustainable food tech.
Climate Entrepreneurship Hub (CEH)	The CEH is a program launched by the UNDP India and the AIM to promote a multi-stakeholder alliance for green innovation and climate entrepreneurship in India. The CEH creates an enabling ecosystem through access to specialized business support and mentorship that are not available at other, more traditional incubators.

(Table 9 continued)

(Table 9 continued)

Program Name	*Description*
Vernacular Innovation Program (VIP)	The VIP is an initiative of the AIM designed to lower language barriers by translating design thinking and entrepreneurship resources into 22 local languages. AIM has created a Vernacular Task Force (VTF) for each language, comprising of vernacular language teachers, subject experts, writers, and members of the regional AIC. The AIM has also partnered with the design department of the IIT Delhi to train all VTFs in design thinking and entrepreneurship concepts to enable them to contextualize and translate these resources to their respective languages. By making educational resources on design thinking and entrepreneurship available in 22 languages, the accessibility of these resources will significantly increase to include previously underserved sections of the population. This will help local communities innovate to find grassroot solutions to their own challenges independently. This initiative will help to improve the accessibility of all programs under the AIM ecosystem including ATLs, AICs, and ACICs.

Source: Atal Innovation Mission.

Notes: *: Aspirational districts is a program launched under NITI Aayog in 2018 with the objective of transforming 112 of the most backward districts across 28 States. The program aims to expedite transformation of these districts through the convergence of central and State schemes, collaboration between all levels of government and competition between aspirational districts. The program focuses on five main themes, health & nutrition, education, agriculture & water resources, financial inclusion, skill development and basic infrastructure; #: Ministries of Defence, Food Processing, Health and Family Welfare, and Housing and Urban Affairs; †: The Ministry of Jal Shakti includes the Department of Water Resources, the Department of River Development and Ganga Rejuvenation; ‡: Startup Réseau is a network of Startups, Enterprises, Capital, Markets, and Services, designed to bring in a structured interface for enabling collaboration in the ecosystem. It was founded in 2019 by Ajay Ramasubramanium in Mumbai and operates across India and Africa. Startup Reseau has conceptualized and operated accelerator programs for various corporates and also actions CSR-driven mandates for the promotion of entrepreneurship and startups.

While these initiatives have made considerable impact, they face some challenges. For starters, startups operate in a fast-paced environment, vastly different from the government bodies that finance them. Lengthy and complicated documentation, cumbersome audit requirements, and an unhurried disbursement of grants slows down their funding. Another challenge is the lack of an integrated inter-ministerial platform to invite innovations that solve national challenges and long-term technological transitions. The AIM is working on addressing these challenges. To fast-track the pace of grant approvals and disbursements, it is trying to transition from a milestone-based to a venture capital-based financing model. The AIM also plans to create 'innovation sandboxes,' forums to bring together academics, innovators, and policymakers on a project basis. These sandboxes will enable a multi-disciplinary approach to solve national challenges like farm productivity, and healthcare delivery, among others.

4.1.4. Deep Dive into the Defence Innovation Organisation (DIO)

The DIO was launched by the Ministry of Defence in 2017 to fund and support innovations in the defense and aerospace sectors (Press Information Bureau, Government of India 2017). The DIO is a non-profit company set

up under the Department of Defence Production (DPP) and seed-funded by Bharat Electronics Limited (BEL) and Hindustan Aeronautics Limited (HAL). BEL and HAL provide the DIO support with technical knowhow and R&D infrastructure. Though the DIO does not fall under the AIM, the AIM supports the DIO via advice on commercial aspects of product development, and through supervisory services by virtue of being represented on the DIO's board.

In 2021, the Ministry of Defence granted the DIO budgetary support of Rs 500 crores over five years, up to FY26 (Press Information Bureau, Government of India 2021).[28] Of this, Rs 450 crores is to be used towards grants to winners of various iDEX (explained below) competitions, Rs 30 crores to develop programs at partner incubators, and Rs 20 crores towards internal operations at the DIO (Government of India 2021f). An additional Rs 1,000 crores has been allotted by the Ministry of Defence for procurement from companies supported by the iDEX in FY 2023 (Government of India 2022g).

The DIO is operationalized through its platform iDEX that supports innovation through two competitions; the Defence India Startup Challenge (DISC), where proposals for predetermined problem statements are invited and the Open Challenge (OC), where companies are invited to present open-ended innovations. Winners of these competitions receive a grant of up to Rs 1.5 crore each (Government of India 2021f). In 2021, the iDEX launched DISC 5 across 35 problem statements, and OC 2. These competitions saw 41 and 4 winners, respectively. In 2022, in addition to launching DISC 6 with 38 problem statements, iDEX also launched iDEX Prime, a competition with 6 problem statements and funding of up to Rs 10 crores for each winner. Saif Automation Services is the first winner of an iDEX competition to secure a procurement order from the Indian defense forces in October 2021. The startup created a battery-operated self-propelled vehicle for water bodies, which can be controlled remotely. This vehicle can be used for search and rescue operations and for disaster relief in flooded areas.

In addition to providing grants to the winners of its competitions, the DIO also bolsters the development of prototypes in numerous ways. The DIO has partnered with 14 incubators at key institutions such as the Indian Institutes of Technology (IITs) and the Indian Institutes of Management (IIMs), through which it supports winners of the competitions from the prototyping stage through to commercialization and procurement. Partner incubators also run programs to mentor entrepreneurs attempting to create defense technologies. The DIO gives partner incubators up to Rs 40 lakhs to run each such program. The DIO aims to increase its number of partner incubators to 50 by 2023. Working with incubators allows the DIO to identify high-potential startups and build a pipeline for its competitions.

28. Financial Year (FY) refers to the 12 months ending March 31.

DIO also provides iDEX winners with technical support by facilitating their access to testing and research facilities, and to the expertise of various defense public sector undertakings. It also facilitates access to senior officials in the defense forces to enable fast-tracked testing, commercialization, and procurement. Winners of the competitions enjoy significant national and international exposure to other participants in the ecosystem, including manufacturers, increasing the potential for collaboration and therefore, the probability of successful commercialization.

4.2. Science & Technology Clusters

An important government initiative to promote innovation in science is the Science & Technology (S&T) clusters project. Set up in 2020 at the behest of the Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC), under the Office of the PSA, the clusters project aims to bridge institutional voids by bringing together academia, the corporate sector, and the local administration in a collaborative ecosystem (see Table 10). The hope is that aggregating stakeholders in an erstwhile siloed and fragmented marketplace will lead to scale economies, trigger synergies in the research and development process, and facilitate transactions between providers and users of research. Robust research universities, anchored in vibrant innovation ecosystems, are key to both absorbing from and contributing to the global flow of idea. S&T clusters have a tri-layered structure of objectives. The foundational layer consists of building an ecosystem of collaboration between participating institutions, for example, in the form of sharing course content across institutes, working on joint R&D projects, etc. The intermediate layer comprises problem-solving in the local community and for the local and State administrations. Clusters may collaborate with external partners such as local incubators to do this. The final layer consists of building sectoral capabilities and expertise to enhance competitiveness, with the ultimate goal of contributing to the strategic objectives of the Government of India (Office of the Principal Scientific Adviser to the Government of India 2022).

One successful example of collaboration between academia and industry in India is the IIT-Madras Research Park. The research park has over 70 partner companies across 17 sectors, has filed over 1,300 patents, and incubated over 230 startups, of which 40 percent have IIT Madras faculty as founders or minority shareholders. Many large companies, such as Saint-Gobain and Mahindra, have set up or relocated their research facilities from elsewhere in the country to Chennai, citing the IIT Madras Research Park ecosystem as the reason. In May 2022, Pfizer invested over Rs 150 crores to set up the company's first global drug development center in Asia at the Park (Business Standard Reporter 2022). Similar instances of collaboration in the West also have a track record of generating tangible results. Geographic clusters such as Silicon Valley, North

Carolina's Research Triangle Park, and Cambridge's bio-cluster, for instance, have attained international prominence for research and innovation.

TABLE 10. Pilot Clusters: Lead Institutions, Focus Sectors, and Funding Raised

Cluster	*Lead Institution*	*Focus Sectors*	*Funding Raised*
Hyderabad	Research and Innovation Circle of Hyderabad	Life Sciences, Food & Agriculture and Sustainability	Rs 4.15 crores from Foundation for Innovative New Diagnostics (FIND), Bill and Melinda Gates Foundation, and Ministry of Agriculture & Farmer's Welfare
Pune	Inter-University Centre for Astronomy and Astrophysics	Sustainability & Environment, Health, Big Data & AI and Sustainable Mobility	Rs 4.19 crores from Schlumberger, Hindustan Unilever, Rockefeller Foundation and Cummins India Foundation
Delhi-NCR	Indian Institute of Technology, Delhi	Solid Waste Management, Water Security, Air Pollution AI/ML in Healthcare, Sustainable Mobility and Effective Education	–
Bhubaneswar	Kalinga Institute of Industrial Technology	Quantum Engineered Advanced Materials, Waste to Value, Wetland Management, Biosciences and Polymer based Interventions	Rs 3.38 crores from industrialist Mr Subroto Bagchi
Jodhpur	Indian Institute of Technology, Jodhpur	Medical Technologies, Handicraft & Handlooms, i-governance, Thar Designs, Water & Environment and IoT Innovation	Rs 15.53 crores from Department of Biotechnology (DBT), Jal Jeevan Mission, Ministry of Jal Shakti, Siemens and Canara Bank
Bangalore	Indian Institute of Science, Bangalore	Health & Wellness, Urban Life and Futuristic Technologies & Solutions	–

Source: The Office of the Principal Scientific Adviser to the Government of India.

So far, the PSA has granted seed funding to six S&T clusters, which function autonomously. The current framework for clusters aims to leverage skills and resources at existing institutions rather than the setting up of new multi-disciplinary institutions and centers. Each of the six clusters is centered on select themes, with the goal of building expertise and capabilities in specific areas. Clusters also operate virtual platforms to bring in domain knowledge from other domestic and international organizations that share a similar mission. Enabling virtual participation allows clusters to collaborate efficiently with non-local actors, improving outcomes.

The S&T Cluster Apex Committee (ST-CAC) is the apex body for the S&T clusters project and is chaired by the Vice-Chairman of the NITI Aayog. The committee formulates guidelines on clusters' selection, operation, and performance evaluation. It is responsible for enabling inter-cluster collaboration, and coordination between clusters, ministries, State governments, and international institutions. It nominates a lead institution for each cluster and lays down principles for the selection of cluster CEOs. The lead institution is responsible for enabling and ensuring collaboration within the cluster, hiring a CEO and other full-time staff, and other activities required to commence operations. For instance, IIT Delhi is the lead institution for the Delhi Cluster, while the Indian Institute of Science Bangalore leads the Bengaluru Cluster. Cluster CEOs typically come with a diverse range of experience from the private sector, academia, and the government.

An important objective of the ST-CAC is to monitor cluster performance through tracking measurable outcomes. Some of these outcomes include the number of solutions commercially deployed, the number of partnerships, patents, and industry-sponsored R&D projects created, and monetary value of FDI brought in. While a structure for accountability is critical, it is also important that reporting requirements are not overly onerous, particularly at initial stages. Each cluster must have the flexibility to explore problems and opportunities in their selected themes freely without being weighed down by the need for approvals, committee reviews, and other bureaucratic impediments.

Clusters are not a recent phenomenon in India. The Department of Biotechnology, for example, established four bio-clusters in 2014 to promote research, development, and entrepreneurship in the sector. The Ministry of Commerce set up the Auto Cluster Development and Research Institute in Pune in 2007. However, possibly as a consequence of being set up within specific ministries, these clusters have not adequately been able to break through existing siloes and collaborate effectively with other institutions. As such the ecosystem of formal and informal networks is still nascent.

4.2.1. Deep-dive into the Delhi S&T Cluster

The Delhi S&T Cluster located at IIT Delhi and founded in 2021 is an example of a cluster that has made tangible progress in shaping the science and deep-tech ecosystem. The cluster currently has over 40 partners across academia, industry, research labs, and the government. Each partner gets access to a platform for collaboration, fundraising opportunities, industry connections, and strategic advisory services (see Table 11).

Currently, the cluster works on six themes,[29] each of which is led by a Principal Investigator (PI) working alongside a multi-disciplinary team of participants.

29. Themes include solid waste management, water security, air pollution, artificial intelligence and machine learning in healthcare, sustainable mobility, and effective education.

TABLE 11. Example of a Cluster's Constituents, Select Participants of the Delhi S&T Cluster

Academic Institutions	• Indian Institute of Technology (IIT), Delhi (Lead Institution) • Indian Institute of Technology (IIT), Dhanbad • Jawaharlal Nehru University (JNU) • Delhi Technological University (DTU) • University of Delhi • Netaji Subhas University of Technology (NSUT) • All India Institute of Medical Sciences (AIIMS, New Delhi) • Indraprastha Institute of Information Technology (IIIT, Delhi) • Ashoka University • BML Munjal University
Government Labs	• CSIR-Central Road Research Institute (CRRI) • CSIR-Institute of Genomics and Integrative Biology (IGIB) • ICAR-Indian Agricultural Research Institute (IARI)
Government Agencies	• Delhi Transport Corporation (DTC) • Delhi Metro Rail Corporation (DMRC) • Delhi Pollution Control Committee (DPCC)
Private Companies	• Tata Power • Mahindra Power • BSES-Rajdhani Power Limited • BSES-Yamuna Power Limited • Google • PhonePe • Panasonic Batteries • Tata Steel • Hyundai • Swiggy • Zomato • BASF • Central Square Foundation
International Organizations	• World Economic Forum (WEF) • United Nations Development Program (UNDP)

Source: The Office of the Principal Scientific Adviser to the Government of India, Delhi Research Implementation, and Innovation (Delhi S&T Cluster).

For each theme there is a stated goal. For instance, the social mobility theme aims to create charging, power distribution, and battery swapping infrastructure. Partners for this theme include IIT Delhi, Tata Power, Mahindra Electric, Maruti Suzuki, Google, Delhi Metro, Delhi Transport Corporation, and CSIR, and it is led by Dr. B.K. Panigrahi of IIT Delhi. A research project in one of the themes led to the development of a technology for recycling e-waste[30] through

30. E-waste signifies electronic products that are unwanted, not working, or at the end of their useful life.

pyrolysis.[31] E-waste constitutes a significant source of waste generated today and can be dangerous if not processed appropriately. The method developed has been patented and published in leading academic journals and was awarded the SRISTI-GYTI[32] in 2020.

Apart from working on the theme's objectives, the cluster also undertakes specific research projects with industry partners. The cluster's development of advanced battery and energy storage solutions, such as battery packs for EVs, in collaboration with Log9 Materials and the Centre for Automotive Research and Tribology (CART), is one example. Another is the collaboration between the Delhi Cluster and a leading Indian two-wheeler manufacturer to set up a center of excellence (CoE) for mobility-based projects. The manufacturer will fund the CoE and work with the cluster on R&D projects, on training and skill development programs, and on exploring potential collaborations with startups.

The cluster also runs an educational and commercialization platform to enable growth and development of entrepreneurial ventures. Its skill development platform, PERKS (Platform for Entrepreneurship, Research, Knowledge and Skill Development), offers participants access to skill development and training programs, and other research infrastructure. Its online course on electrical engineering deployed in EV charging infrastructure, in collaboration with the CART, is accessible to all, enabling broad dissemination of knowledge generated at the cluster. In addition, the cluster is working on a startup and innovation platform that will support companies between Technology Readiness Levels (TRL)[33] 4-7 with technology development and demonstration.

While the cluster's progress has been appreciable, it still faces numerous challenges. For one, the governance structure and reporting requirements are convoluted. Also, there remains a lingering apprehension amongst cluster participants about collaborating openly with partners, and moving away from the existing model of clear institutional silos. Finally, finances are also a challenge. It will be important for the cluster to raise funds from industry partners to ensure continued support for R&D projects and entrepreneurial ideas.

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31. Pyrolysis is the heating of a material, such as biomass, in the absence of oxygen.

32. The Gandhian Young Technological Innovation (GYTI) award is given in collaboration with the Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI), to individuals in the field of engineering, science, technology, and design.

33. Originally introduced by NASA, the TRL is a scale with nine levels for describing the maturity of a technology from the idea stage (TRL1) to the highest degree of application, commercial readiness (TRL9).

4.3. AIM – Program for Researchers on Innovations, Market-Readiness and Entrepreneurship (PRIME)

AIM-PRIME was launched in 2021 by the AIM in collaboration with Venture Center Pune,[34] Pune Knowledge Cluster,[35] Office of the Principal Scientific Adviser, and Bill and Melinda Gates Foundation. The program brings together three key stakeholders: entrepreneurs at science-based startups, managers of incubators, and academicians, with the goal of taking research from labs to the market. It is a program to expedite the scaling of science-based startups over a period of nine months.

The PRIME program is a nine-month virtual education program which comprises three months of instructional sessions followed by six months of mentorship. The program is focused on four themes; energy and the environment, health and rehabilitation, industrial automation and IoT, and nutrition and agriculture, and offers resources across five scientific disciplines: chemicals and materials, biological sciences, electronics, mechanical engineering and design, and data analytics and computing. During the program, startups and academicians are paired with an incubator where they concurrently work on their ideas while completing the program. The instructional sessions cover broad topics of entrepreneurship such as marketing and funding as well as topics more pertinent to science-based innovation such as an intellectual property management and regulatory strategy. The sessions consist of a combination of lectures, class exercises, panel discussions, and milestone presentations. To increase the accessibility of these sessions, they are recorded and posted on the program's public YouTube channel.

The classroom module is followed by six months of mentoring from experts from leading academic institutions, corporates and the Venture Centre, Pune. The program also leverages global experts to enable international collaborations and partnerships. Mentorship sessions cover topics including business model development, lab to market strategy, IP and regulatory strategy, and funding opportunities. During the first cohort, teams cumulatively received over 635 hours of mentorship over the six-month period with the highest team receiving over 70 hours. Providing mentorship at early stages can significantly benefit startup progress.

The program's first cohort was launched in 2021. Applicants were screened based on their educational background, professional experience and IP holdings. Applicants' product proposals were also screened on parameters including novelty, knowledge intensity,[36] and progress on commercialization. AIC

34. An incubator focused on science and technology startups that was established by the CSIR's National Chemical Laboratory (NCL), Pune, and is supported by the Department of Science and Technology.

35. A S&T cluster hosted by Inter-University Center for Astronomy and Astrophysics.

36. The extent to which a firm depends on its knowledge as a source of competitive advantage.

members were screened on the number of science and deep-tech incubatees at their centers. The cohort had 64 participants from 16 incubators, 8 academic institutions, and 16 startups. Participants were divided in 25 teams, with each team consisting of a minimum of one entrepreneur or faculty member, and one member from an incubator.

Participants demonstrated tangible progress through the course of the program. Progress towards commercialization, measured by Technology Readiness Levels (TRLs), increased by up to two levels during the program. TRLs are a method for understanding the maturity of a technology with TRL 1 representing the idea stage, and TRL 9 representing a product/service with proven operational success. The readiness of proposed technology was also measured on five other metrics including, team, customer, business, IP, and funding. For instance, under the Customer Readiness Level (CRL) evaluation, ideas were assessed on commercial and market viability. While CRL 1 represents hypothesizing on possible customer needs, CRL 9 represents widespread deployment of a scalable product. By the end of the program, participants saw a 22.6 percent rise in performance across all five parameters, with funding readiness increasing the most, by 30.1 percent. Participants also filed for 24 patents, of which 6 were granted, and won over 22 awards and competitions, including the iDEX, Dassault Systems 3D Experience Global Pitch- Paris,[37] Ministry of Electronics and Information Technology (MEITY) Grand Challenge, and Social Alpha's SBI Techtonic Program.[38] This enhanced their visibility within the science and tech ecosystem.

Another initiative under AIM-PRIME is the PRIME investor panel, which brings together investors to mentor participants, to raise funds for proposed ventures, and to increase awareness amongst the investor community on investment opportunities in science. This initiative brings together angel investment networks, VCs, incubators, and the government, at various forums, including, panel discussions, lectures, mentorship programs, and demo-day evaluation dates. It includes investors from organizations like Venture Centre Pune, Indian Angel Network, Social Alpha, Kotak Investment Advisors and Centre for Innovation, Incubation and Entrepreneurship (CIIE) at the IIM Ahmedabad. This, amongst other initiatives, has helped AIM PRIME participants raise Rs 20 crores. While this initiative is a step in the right direction towards building a funding ecosystem for science and deep-tech startups, funding has so far been highly concentrated with just one company attracting over 50 percent of total funds raised. Over time, as this program is scaled up to include more investors and good quality startups, we can expect to see greater allocation and diversification of funding.

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37. A platform that connects people and business to promote sustainable innovations.

38. A program that supports innovations rooted in science and deep technology in the fields of health, education, climate change and agriculture.

AIM-PRIME is also building an ecosystem to support graduates of the program. It runs PRIME services, through which it provides mentoring and related support to graduates. It also hosts road shows and demo-days for graduates to promote their ideas, and to build investor awareness for funding opportunities in science and deep-tech.

The PRIME Playbook and the PRIME library were launched as outcomes of the first cohort. These programs aim to increase accessibility of educational materials to the broader public. The PRIME playbook is a guide for science-based entrepreneurs and faculty on how to bring research from labs to the market. It covers important concepts such as regulatory and IP management, funding and financial management, networking, and negotiation. It also contains templates for capital structure, evaluation of commercialization potential of R&D, and innovation opportunity maps. The PRIME library compliments the playbook and is a collection of curated links of books, articles, reports, videos, and websites across various business and tech focused topics.

The PRIME program is positive in intent. Many ventures emanating from the first cohort of the program have seen early signs of commercialization and funding success, and have won various awards. The fact that the entire program was run virtually is encouraging for future scalability. Though still too early to reliably measure impact, PRIME has significant potential to positively impact the science and technology ecosystem in India.

5. Summary

India should reinvest in the science-entrepreneurship nexus.

Of course, this must start with a recommitment to investment in basic science. The American inventor and policymaker Vannevar Bush's description of Science as the Endless Frontier in 1945 rings more true today than ever with the explosion of scientific insight (Bush 1945).

Equally, we need entrepreneurs to feed at the trough of this scientific cornucopia. This requires alleviating the mistrust that bedevils collaboration across scientific fields and between scientists and entrepreneurs. It also requires the creation of public goods that remove the informational and contracting voids that prevent consummation of transactions between scientists and entrepreneurs (the sell-side and the buy-side of scientific ideas).

The institutional experiments that I have highlighted in this note (and many others, such as Startup India, UIDAI, Unified Payments Interface, and several at individual States) show the feasibility of the needed policy entrepreneurship. But our rhetoric needs to be even more aspirational rather than self-congratulatory, with the policy will to match.

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To view the entire video of this IPF session and the General Discussion that ended the session, please scan this QR code or use the following URL
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Comments and Discussion*

Chair: **Nirvikar Singh**
University of California, Santa Cruz

V. Ramgopal Rao

IIT Delhi

A lot of issues that have been raised in the paper need to be addressed for optimizing deep-tech research and fostering partnerships between industry and academia for carrying out such research in India. In the past six years, 23 alumni of the Indian Institute of Technology (IIT) Delhi have created unicorns, with the similarity among them being that all of them had BTech degrees and families that had some sort of small businesses; they came to IIT Delhi to get a degree and just created businesses, which came very naturally to them. Almost every second student at IIT had an interest in entrepreneurship rather than striving to indulge in deep learning or planning to go for PhDs.

In contrast, IIT Bombay produces about 400 PhDs every year and not even one per cent of them are interested in entrepreneurship, as all of them want to pursue post-docs and faculty positions. What is missing is, therefore, the relevance of the research that is conducted in these institutions. The students at IIT Bombay usually analyze the literature pertaining to the existing problems, get the required funds, execute the project, and write a few papers without exploring how the outcome of that research might help in answering a new question, and also how it may add to the knowledge frontier, specifically for India.

In order to ensure the relevance of the research at such institutions, there is a need to connect with other stakeholders, with industry, society, and strategic agencies, which is done aggressively at IIT Delhi. For instance, at IIT Delhi, there were at least 100 faculty members who worked on research problems funded by the Defence Research and Development Organisation (DRDO), and many of these subsequently became technologies. Hence, initiatives were launched to create more immersion programs in the institution, in order to connect with people and the society, flag the problems, and provide their solutions. In this context, the Grip Grassroot innovation program is

* To preserve the sense of the discussions at the India Policy Forum, these discussants' comments reflect the views expressed at the IPF and do not necessarily take into account revisions to the conference version of the paper in response to these and other comments in preparing the final, revised version published in this volume. The original conference version of the paper is available on NCAER's website at the links provided at the end of this section.

an important initiative wherein the faculty and students can identify a local problem and work towards its resolution, with the institute's support. Taking this idea forward for encouraging faculty to become entrepreneurs, a scheme called Faculty Innovation and Research-driven Entrepreneurship (FIRE) was also started, wherein any faculty member wanting to become an entrepreneur was offered a funding of Rs 50 lakh as a grant, and given a sabbatical to start a company (prior to this, a sabbatical was given only for taking up a teaching assignment abroad), with all the resources being provided by IIT. The success of these initiatives was reflected in the fact that at IIT Delhi, every second faculty member started a startup. A national-level process, including the setting up of a PhD incubator, was also launched.

These initiatives would, however, be more effective if they are managed directly by the faculty rather than bureaucrats. The biggest challenge is to procure sub-critical funding, which is increasingly becoming a bureaucratic issue. The ability of an institution to fund innovation is also rapidly diminishing. For example, an analysis was done at IIT Delhi, wherein all the data pertaining to the previous five years of research funding was examined. The average overhead that institutes received towards five years of research funding amounted to about Rs 1500 crores, the average overheads that the institute received was 5 percent, and the institute was spending about 12 percent on these projects. Thus, the more research the institutions carry out, the poorer (worse) they become. Consequently, our ability to invest in any research is actually diminishing, and the biggest challenge faced by these institutions is to become multi-disciplinary, start new programs, admit more students, and recruit more faculty. Since IIT funding is not linked to the number of students, if sometimes some director becomes more enthusiastic and starts multiple programs simultaneously, the institute again turns poor because the Ministry of Education does not assess the number of students being offered funding. One major policy challenge in India is thus to put in place a proper financial model for running higher educational institutions like the IITs.

Patenting is another critical issue, as the patent-to-publication ratio can also link research to innovation. An analysis of global data in the sphere of nanotechnology, especially in the USA, which is a hub for innovation, reveals that a patent is filed there for every five papers written by scholars on subjects related to nanotechnology. In, India, on the other hand, a patent was traditionally being filed for every 300 papers written. This number has since been brought down to one patent for every 18 publications.

Another challenge is to promote multi-disciplinary research. Until now, there was no scheme whereby two faculty members from two diverse departments or from two different institutes could come together to conduct a research study. Hence, we undertook an experiment at IIT Delhi, wherein if two faculty from two different departments or from two different institutes in the country would come together to write a coherent proposal addressing a social problem, the

institute would offer each of the faculty members a seed grant of Rs 5 lakhs per year for two years. Thus, a total amount of about Rs 20 lakhs was spent on such multi-disciplinary projects with the condition that after two years, the researchers would have to seek extra support funding from other agencies. About Rs 12 crores have been spent on supporting such multi-disciplinary research at IIT Delhi over the last four years, with returns of about Rs 180 crores accruing from this experiment in the form of additional funding brought in by the faculty members engaged in this research.

It is imperative to devise and implement more such schemes in the country. This could be done by providing funding for such research to universities across the country, and also by encouraging faculty from Tier-1 institutes to interact with and write joint proposals with their counterparts from Tier-2 and Tier-3 institutes. These schemes can create widespread motivation among people from different institutions. A lot of good research is taking place in academia, which could meet the requirements of industries. However, such cross-cutting collaborations are hampered by the lack of interaction across both institutions and ministries.

This situation could change with the new National Education Policy 2020 envisaging the setting up of a National Research Foundation (NRF) to strengthen the research ecosystem in India by improving linkages between Research & Development, academia, and industry. Many agencies are now also providing funds to startups, including deep-tech startups and a large number of faculty of academic institutions are considering launching their enterprises. However, they need to be provided training and support in the areas of quality control, manufacturing, and marketing. It is thus important to create an entity which not only funds but also provides advice and technical assistance to such budding entrepreneurs. Such agencies already exist in other countries, which can be analyzed for their best practices. For example, the Industrial Technology Research Institute (ITRI) in Taiwan acts as a bridge between academia and industry, and can be seen as a role model for creating such entities in India too.

Thus, what is needed is a little reorientation in the research ecosystem to enable India to enter the deep-tech space. The focus needs to shift towards funding national programs to promote research activity by the faculty, entrepreneurs, and universities for harnessing the vast academic talent available in the country. India can do as well in the arena of deep-tech entrepreneurship as it has done in the e-commerce and other spaces.

Chintan Vaishnav
NITI Aayog

This paper identifies several critical gaps in the innovation ecosystem, specifically relating to science-based entrepreneurship. It paves the way for

promoting science-based entrepreneurship by taking forward the perspective on the different dimensions it talks about, and the insights it generates. Our innovation ecosystem today broadly caters to those who are proficient in English, accounting for only about 11 percent of our population. Comparing that, say with Israel, which ostensibly has one startup for every 2000 citizens, we have 70,000 startups today, which for a population of 1.3 billion people, equates to one startup for every 20,000 citizens.

While a lot more work needs to be done in this area, we at NITI Aayog have launched a number of initiatives to boost science-based entrepreneurship across the country. A significant example of this, also mentioned in the paper, are the Atal Tinkering Labs established under the Atal Innovation Mission to foster curiosity, creativity, and imagination in young minds; and to inculcate in them skills such as design mindset, computational thinking, adaptive learning, and physical computing. We have built 10,000 such labs, but considering that there are 260,000 secondary and higher secondary schools in the country, clearly 10,000 is a very small fraction of that, and we need to do much more work infrastructure-wise.

The next layer that we need to work on is that of the human resources which utilize these labs. Thereafter, as regards the third layer where specialization begins to occur with a sector-wise innovation ecosystem, we built something called iDex, also flagged in the the paper. This initiative is aimed at fostering innovation and technological development in the Defence and Aerospace ministries by encouraging innovators and entrepreneurs to deliver technologically advanced solutions for modernizing the Indian military. iDEX will engage industries, startups, R&D institutes, and academia, and provide them financial and technological support to undertake R&D for fulfilling India's defense and aerospace needs.

We are also in conversation with several other ministries for establishing a similar platform for their respective sectors. This third layer of the entrepreneurship pyramid is in the early adopter stage with ongoing discussions with the ministries.

The paper really gives us the ammunition to tell these ministries that there are real returns for investing in research. One major challenge in writing such a piece as well as reading it is that most of the advanced ecosystems in the USA, such as in the Bay area, or Boston, are over 40 years old. The question that needs to be addressed is as to what were they like when they were ten years old, and whether they faced a similar skew in terms of excessive favoring of some sectors as compared to the others, and the types of deep science challenges they encountered in the early years of their inception.

The paper offers some dynamic insights. First, it makes a solid argument about the funding ecosystem, the availability of funding, and the low throughput of the ecosystem in terms of the incubators. The funding availability is a capacity of the ecosystem, while the throughput needs to be evolved by the stakeholders

in collaboration with each other, not independent of each other. If the funding suddenly increases and it is not utilized efficiently, there is a loss of investor confidence.

On the other hand, if infrastructure increases independent of funding, then too there would be a loss in terms of the young innovators feeling that though they came up with a bright idea, it could not be fructified due to lack of funds. This could compel the young talents to give up the original projects and seek funding elsewhere. This co-evolution idea is thus a major contribution of the paper.

The other important argument made in the paper pertains to the public-private research funding and the very low quantum of funds we are currently investing as a nation on research. This dovetails into the idea of early stage grants and investments for deep science entrepreneurship, which has a deep and wide value. Thus, the idea of greater research funding, on one hand, and fostering more risk-loving early-stage grants, on the other hand, must coalesce to enable us to overcome scientific uncertainty at an early stage, which again is an idea promoted by the paper.

The third thing concerns the multiplier over how we have invested so far and the returns from early innovation incubation centres. This is the first time that such a back-of-the-envelope calculation has been made, and it has a direct impact on how we write our next Cabinet note, as it turns the idea of returns into a formula, assimilating the returns from a value created by startups, by incubators, and by tinkering labs, among others, in the entrepreneurial space. If we look at this formula from the perspective that technology is only a non-linear variable, then the returns of the first five years cannot be the same as those of the second five years, and there has to be a multiplier greater than the one for the second five years. One thing that would lead to that multiplier effect is the extensive utilization of the available infrastructure. iDex, however, achieved a return of 50 times because there was no need to build the infrastructure. The paper also offers the argument that this process has to be carried out for industry after industry, accompanied by the information that the infrastructure already exists but needs to be utilized for integrating innovation into the industry sector. This thought presented in the paper will also translate into our cabinet note.

The idea that the foundation for deep science entrepreneurship cannot come without academic strengthening is not adequately discussed. The paper talks about the AIM-Prime program, which envisages promoting science-based, deep-technology ideas to market through training and guidance provided over a period of nine months. The main intent of such a program is to take ideas from the lab to the land, and demystify that process to the extent that the program could. The booklet that it produced called the AIM-Prime playbook has all these frameworks, which guide readers in their choice of science-based entrepreneurs. A deep-science ecosystem is also missing for innovation. Further, highlighting the significance of the manufacturing capability, creating a prototype and small

trials is easy but designing for manufacturing is a very different area altogether, and poses a major bottleneck for many start-ups. Second, the absorption capacity or the market creation for a particular startup is a difficult proposition, and this is where the government ought to step in. Finally, with reference to human resources and skill development, we are scaling the infrastructure but we also need to scout for human resources or managers who would consider these different deep-science and technology creation and innovation areas as long-term career choices.

General Discussion

Michael Kremer commenced the discussion by asking for details about the sale value of a company in Bengaluru mentioned by the author in his presentation. He assumed that there was some reason why the legal transaction for changing ownership of the company could not be undertaken. Presumably, this was because the location of the company had been changed through some internal purchase to Boston from India. He asked if the company wanted more employees based in Boston or if the ownership change could not be effected through a legal transaction.

Tarun Khanna responded that there are frictions in the form of taxation, as the country where the enterprise originated is understandably reluctant to accept them. Further, redistribution also takes place due to lack of synchronization of the tax scores. Besides, the buyers have the bargaining power due to lack of a vibrant market in the original location. Arvind Panagariya asserted that the bargaining power of the buyer should not be dependent on the location of the company. Karthik Muralidharan reiterated that the issue could have to do with the labelling of customer needs and the dynamics of the local markets.

Govinda Rao wondered why the private sector in India is not forthcoming in making investments in the specified areas. Was this because they still enjoy a lot of protectionism or because they want to sell off the existing companies? This is a matter of concern because the private sector leads many science-based entrepreneurships elsewhere.

Deepak Mishra wanted to know what market failures and government failures was the New Lab trying to solve, especially in terms of critical issues that are being addressed by this particular lab vis-à-vis a global innovation hub like the US. He also questioned as to whether the sub-title of the paper, "A Policy Glass Quarter Full", pertains to the perception that only a quarter of India's potential is actually being achieved, and how far this can be contextualised in the current economic environment prevailing in India.

Anup Malani asked the author about the importance of innovations in terms of the scientific, legal and financial infrastructure relative to science. If only

the scientific issue were resolved while the other issues were left unaddressed, it would become a limiting factor for the proposed innovations. He also asked Ramgopal Rao why it was difficult outside of the IITs to generate a start-up infrastructure or a start-up atmosphere. It is imperative to identify the difficulties with university administration in India versus places like the United States, where the start-up culture has been embraced across a broader range of universities, and not just in the technical universities.

Tarun Khanna replied that the private sector issue relates to the new lab infrastructure issue. Even in the US context, where the market infrastructure for science-based entrepreneurship is much better than in other countries, it is important to consider experience and the need to deal with people of different mindsets, such as a researcher in a lab versus an executive who has to answer to clients and shareholders on issues like quarterly earnings and reports. As regards the legal infrastructure, he suggested that such an ecosystem is well established in India, reflected in the existence of intellectual property lawyers, who are cognizant of systems and processes and the functioning of global companies operating out of India currently, which trains them to deal with different types of IP regimes and patenting regulations.

Ramgopal Rao averred that in order to overcome the lack of confidence exhibited by corporates in funding new startups helmed by academia, there is a need to deal with the challenge of collating coherent data, and convincing the government to provide substantial funding for startups. The issue of extensive homogeneity and lack of cultural diversity in Indian academic institutions also ought to be addressed. For this, it is essential to engender multi-disciplinary institutions of higher learning and to foster structural changes in the existing academic institutions. Chintan Vaishnav flagged the question of lack of private sector interest in providing funds for startups, and noted that enterprises need to see improvements in both their top and bottom line outcomes as a result of engaging with the startups, resulting in higher market shares and improved profits, respectively.

Bornali Bhandari cited a specific NCAER project on improving farm mechanization in India and ways of making India a production hub for farm machinery. One of the big challenges in this sector is the insufficient R&D in this particular industry, for which the solution again lies in enhancing collaborations between academia and industry. Discussions with private entrepreneurs and the Indian Council of Agricultural Research institutes run by the government revealed that while the private players are largely driven by the aim of augmenting profits, the public institutes have access to research expertise and interest but are unable to forge sustained partnerships with private parties, essentially because they would not be producing a public good. Thus, though both the private sector and public sector enterprises are keen to partner with each other, this interest does not fructify into results on the ground.

One of the solutions could be the implementation of legislation like the Bayh-Dole Act, or an Act enabling public universities to partner with private parties, to produce goods, and create a productive R&D environment. Secondly, while the USA is undoubtedly a global innovation hub, one of the countries that has done quite well in terms of the academia-industry collaboration is Turkey, which offers rich examples of creating techno parks, and Science, Mathematics and Technology (SMT) clusters through an exchange between the public and private parties. Simultaneously, it is also imperative to generate patents to facilitate commercialization of the innovations.

Ruchir Agarwal alluded to the creation of a Bio Valley in Malaysia, in the book, *The Boulevard of Broken Dreams* by Josh Lerner, which ends up becoming a valley of bio-ghosts. In this context, public efforts need to be encouraged to scale up entrepreneurship in Indian cities to prevent them from suffering the same fate as the Malaysian Valley.

Karthik Muralidharan argued that if government funding for startups is bureaucratic and private funding depends on high returns on investment in a finite time horizon, the startup ecosystem is probably a fertile space for philanthropic funding, which is currently confined to the building of schools and hospitals in India. Taking the issue of philanthropy further, Sonalde Desai said the concept of industry CSR funding could also be considered. The Indian Government has actually mandated a certain percentage of CSR spending by the industries. So, in certain big growth areas like biometrics, auto parts, and pharmaceuticals, innovation could be encouraged by allowing these industries to initiate some deep-science funding in their respective areas.

Manish Sabharwal pointed out that as regards location-based valuation, 25 percent of the public markets are owned by foreigners, and 50 percent of the non-founder ownership of public markets rests with foreigners. But software, pharmaceuticals, consumer and services companies trade at higher multiples in India than they do in the US. Therefore, location-based valuation is advisable and for companies like Dr Reddy's or Tata Consultancy Services (TCS), it is more beneficial to be listed in India.

Ramgopal Rao highlighted the significance of a composite financial model, comprising CSR funding and creation of endowment funds for academic institutions on the lines of similar funding undertaken for universities in the USA. Perhaps the Indian government can mandate that 1 percent of the CSR must go to educational institutions. He revealed that IIT Delhi was the first institute in 2019 to launch a billion-dollar endowment fund. Another source of finance for American universities is that of overheads from research projects, which is conspicuously absent in India. Chintan Vaishnav stated that he had initiated discussions with a variety of stakeholders to create a hub like the New Lab, which would be distinct from the concept of clusters. What is also needed is a viable system of intermediation and a deep-tech climate to generate

sufficient interest in science-based entrepreneurship in the country by fostering handshake mechanisms between entrepreneurs and scientists.

Concluding the discussion, the Chair, Nirvikar Singh remarked that the new National Education Policy offers some hope of fresh thinking and flexibility in encouraging innovations, especially in specific areas where things can be improved without difficult institutional interventions. There is thus some supremely low-hanging fruit that India can and should take advantage of, without further delay.

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POONAM GUPTA*
NCAER

ARVIND PANAGARIYA**
Columbia University

Privatization of Public Sector Banks in India Why, How and How Far?§

ABSTRACT Banks play a critical role in economic growth. In India, the banking sector, dominated by public sector banks (PSBs), has underserved the economy. The underperformance of PSBs has persisted despite several policy initiatives during the past decade. Meanwhile, private banks have further improved their performance and have gained significant market share. In this paper, we have made the case for privatization of PSBs. Keeping in view India's development needs and superior performance of the State Bank of India, we propose that the latter be held in the public sector for now but all other PSBs be privatized. In order for them to set an example for the success of future privatizations, the first two banks for privatization should be the ones with better asset quality and higher returns. The most critical element for privatization to succeed would be the withdrawal of the government from the post-privatization board of the bank. The paper proposes a couple of different pathways to successfully transition the sector toward private ownership. It cautions that the status quo will result in further erosion of the market share of PSBs toward oblivion, while impeding India's economic growth and inflicting substantial costs onto the depositors, firms, taxpayers and the government as their majority owner in the interim.

Keywords: *Bank Credit, Public Sector Banks, Privatization, India*

JEL Classification: *G21, G28, K23, L33, E23*

* *pgupta@ncaer.org*
** *ap2231@columbia.edu*
§ The authors are grateful to Ashish Gupta, Manish Sabharwal, Mridul Saggar, and Nilesh Shah for extremely useful suggestions.

1. Introduction

Finance is the lifeblood of an economy. Banks have a special role in ensuring that this lifeblood flows from the source where it is generated to the parts of the economy that exhibit the highest growth potential. This function assumes special importance in developing countries since the available finance is scarce and returns across projects show a high degree of variance. The problem is compounded by relatively underdeveloped capital markets in the early stages of development, as this means that savers lack the instruments to directly invest in enterprises that promise high returns. Intermediation through the banks is their principal hope of earning decent returns on savings.

Poor investment choices by banks do not only lead to poor performance by the economy but also undermine the banking system itself. Such choices result in frequent defaults by borrowers and the accumulation of large losses by the banks. The latter, in turn, threaten a default by banks themselves on their obligations to the depositors. Since depositor interests are difficult to ignore in a democracy and large losses by banks pose a systemic threat to the economy, the government has to come to their rescue using valuable taxpayer resources. To avoid such episodes, it is important that banks are subject to commercial pressure and are closely monitored and regulated.

In India, banks have done a generally poor job of lending, resulting in frequent defaults on repayments, and consequently episodes of large accumulations of non-performing assets (NPAs).[1]

In turn, the government has had to repeatedly deploy massive volumes of taxpayer money to recapitalize the banks to jumpstart stalled lending and pre-empt financial crises. Central to these repeated NPA episodes has been the public-sector ownership of banks, accounting for three-fifths of banking assets. As we will see, the NPA problem is primarily concentrated in these Public Sector Banks (PSBs) and, indeed, they have been the sole beneficiaries of recapitalization financed by taxpayer money. Our view in this paper is that without transferring the ownership of these banks into private hands, the banking sector in India cannot be placed on a path to the sustained growth free of repeated episodes of NPAs. In principle, it is possible to reform PSBs while keeping their ownership in government hands but in practice, such reform has not happened and is unlikely to happen within the bureaucratic system of India. Hence, it is essential to focus on making the case for the privatization of PSBs and outlining the possible paths to it. This, therefore, is the task we set for ourselves in this paper.

Before we turn to the main subject of the paper, however, we find it useful to provide the reader a brief post-Independence history of banking in India.

1. Figure A1 in the appendix to this paper provides a comparison of the bank NPAs in India with those in other countries.

Accordingly, we offer a bird's eye view of the evolution of banking in India from Independence to 1991 in this introduction. Thereafter, in Section II, we present a slightly more detailed picture of the evolution of the key indicators during the three decades beginning with 1991. We then turn to an assessment of PSBs versus private banks (in Section III), making the case for privatization (in Section IV), and outlining the possible paths to it (in Section V). We conclude with a long summary of the paper (in Section VI).

At the time of Independence, all Indian banks were private. Even the Reserve Bank of India (RBI) was not entirely in the public sector until it was nationalized in 1948. In 1955, the government created the first public-sector commercial bank, the State Bank of India (SBI), by nationalizing the Imperial Bank and merging former State-owned and State-associated banks with it. In 1959, the government took over another eight State-associated banks, making them subsidiaries of SBI. These actions brought one-third of the then banking assets into the public sector.

There were two further episodes of nationalization. In 1969, fourteen private banks, each with Rs 500 million or more in deposits, were nationalized. In 1980, another six private banks, whose deposits had come to exceed the Rs 500-million threshold by then, were nationalized. These nationalizations placed the government firmly in control of the banking sector and at least until the launch of the economy-wide reforms in 1991, market forces had little play in the sector.

Between 1969 and 1991, the government pursued two main objectives: expansion of bank branches into rural and semi-rural areas to bring banking to them, and redirection of credit to the "priority sectors", which it considered underfinanced. The bank-branch-expansion program led to the opening of many unviable bank branches and was formally discontinued in 1990. Priority-sector lending contributed to the problem of NPAs, which has plagued the sector repeatedly since formal norms for such classification were first adopted in 1985.[2] Despite the recommendation by the Narasimham Committee I as early as 1991, priority-sector lending has not been phased out (Narasimham 1991).

Prior to post-1991 liberalization, RBI controlled nearly all borrowing and lending interest rates, and was the final decision-making authority on all loans of Rs 40 million or more. It also engaged heavily in financial repression by setting the Cash Reserve Ratio (CRR) and Statutory Liquidity Ratio (SLR) at ultra-high levels. The result was slow growth of the banking sector such that bank credit was barely 24.1 percent of GDP till as late as 1991-92. In this backdrop, let us consider the evolution of some key banking-sector indicators during the last three decades.

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2. Figure A2 in the Appendix provides a comparison of NPAs in the priority sectors and the remaining ones. NPAs in priority sectors had remained lower than those in the remaining sectors until 2014–15. But once the RBI tightened norms on the restructuring of loans, the former rapidly ballooned relative to the latter.

2. Evolution of Key Indicators: 1991–2021

Taking the banking sector as a whole, Table 1 provides the values of assets, deposits, credit, and credit to the private sector as proportions of GDP at the end of financial years 1991–92, 2000–01, 2010–11, and 2020–21. All the four indicators, especially assets and credit, show the fastest growth during the middle of the three decades covered.

TABLE 1. Size of the Indian Banking Sector as a Percent of GDP: 1991–92 to 2020–21

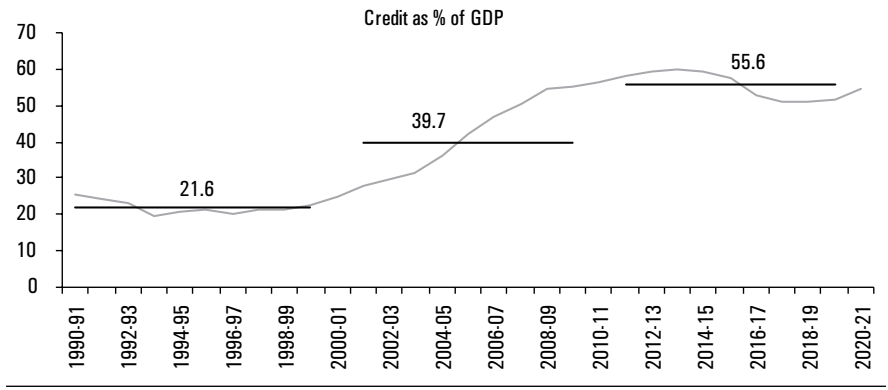
Indicator	*1991–92*	*2000–01*	*2010–11*	*2020–21*
Assets	51.6	60.5	94.1	99
Bank Deposits	40.1	49.3	73.6	78.7
Bank Credit	24.1	24.6	56.3	54.6
Credit to Private sector*	21.7	21.0	51.6	49.4

Source: Reserve Bank of India statistical tables.

As is now well known and we shall further document below, the decade 2004–14 saw extra rapid expansion in bank lending and a significant part of it without due diligence. The result was the accumulation of a massive volume of NPAs and sudden brakes on lending in the second half of the decade of the 2010s. Albeit, deposits as a proportion of GDP expanded more rapidly during the decade of the 2000s as well but whereas they increased by less than 50 percent, credit as a proportion of GDP expanded by more than 100 percent.

Figure 1 graphically depicts the phenomenon of rapid credit expansion: It saw massive growth in relation to GDP until approximately the mid-2010s. The

FIGURE 1. Evolution of Credit as a Proportion of GDP: 1991–92 to 2020–21

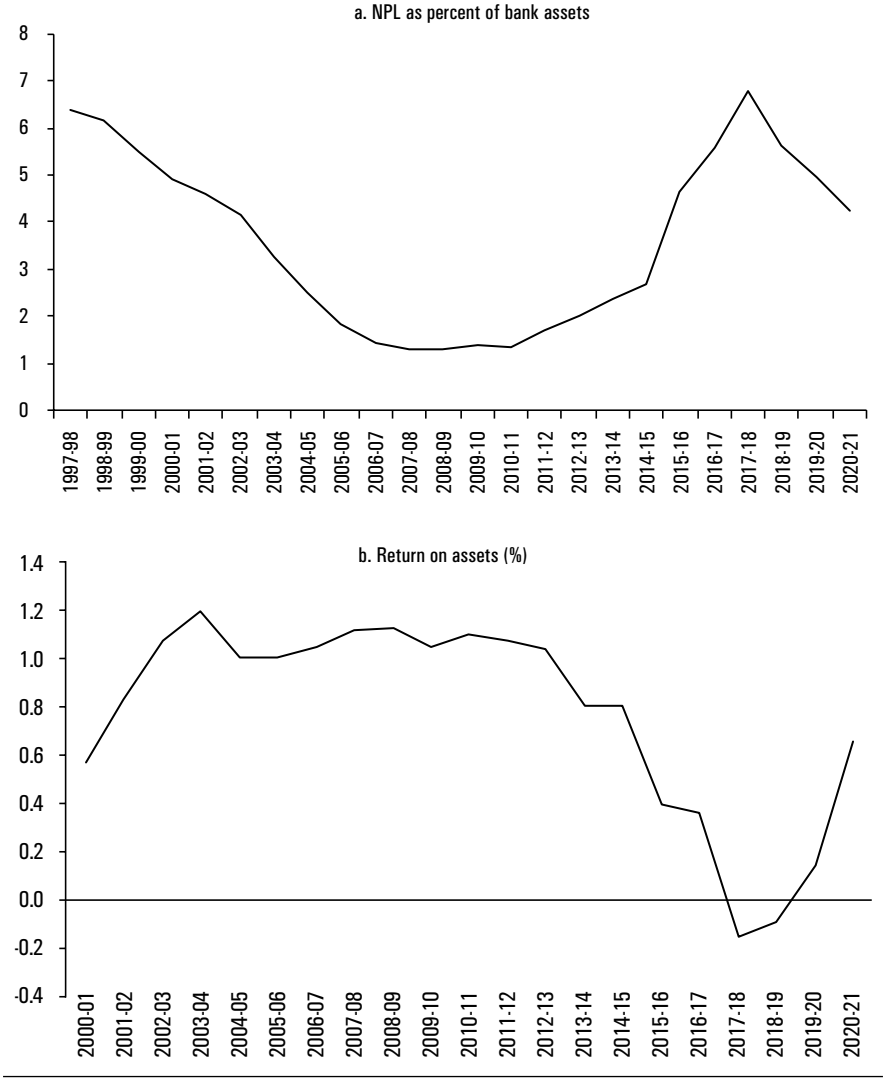


Source: RBI, Basic statistical return (BSR-1), Annual credit by Scheduled Commercial Banks.
Note: Horizontal lines denote the decadal averages.

process then reversed itself with shrinking of the credit-to-GDP ratio. Despite some recovery subsequently, the credit-to-GDP ratio in 2020–21 remained below the level it had achieved a decade earlier in 2010–11.

The fact that loans were indeed advanced to unworthy borrowers during the rapid expansion phase of credit is evidenced prima facie by the evolution of NPAs and the return on assets, as depicted in the upper and lower panels, respectively, of Figure 2. From the 6 to 7 percent range in the late 1990s, NPAs

FIGURE 2. NPAs and the Return on Assets: 1997–98 to 2020–21



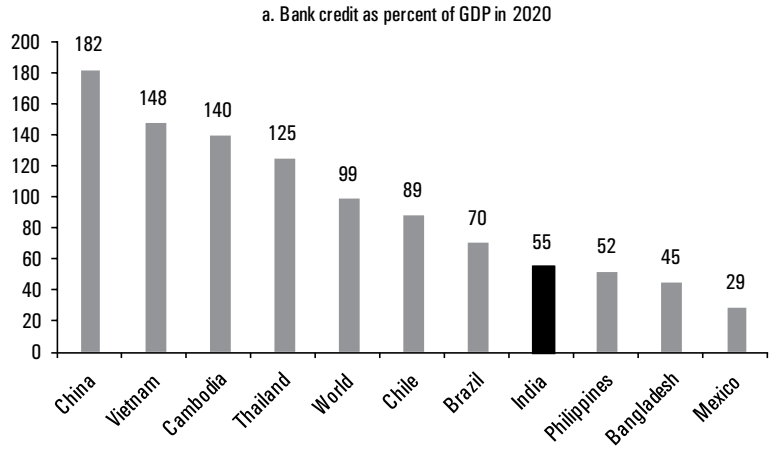
Source: RBI, Handbook of statistics on Indian economy, Statistical Tables relating to banks in India.

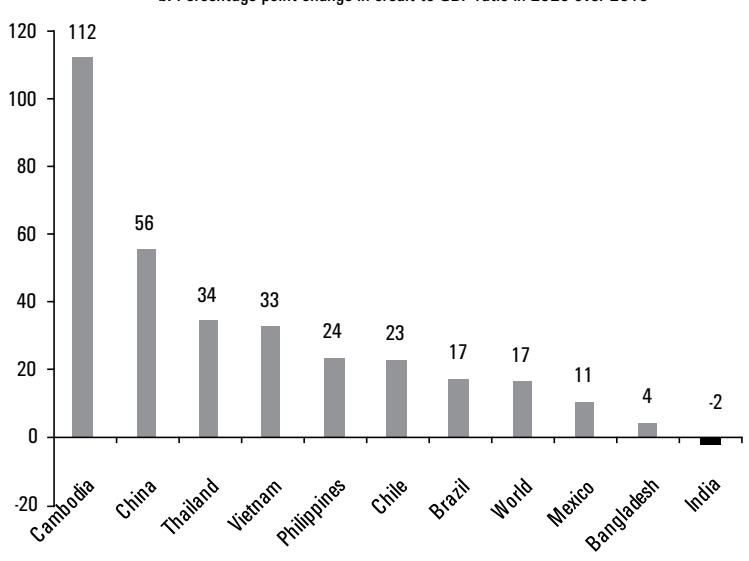
fell in the subsequent years as bank assets expanded during the 2000s, but they again rose sharply after 2014–15, returning to their 1997–98 level by 2017–18. This latter period also saw a sharp decline in the returns on assets. It was only after the government infused massive capital into the banks that both indicators began showing some improvement.

The result of the twin facts of slow expansion of credit prior to 1991 and lack of net expansion of the credit-to-GDP ratio during the 2010s has been that India remains well behind comparator countries in terms of bank-credit penetration. This fact is captured in Figure 3, in which the upper and lower halves show the credit-to-GDP ratio in 2020 and the percentage points growth in its value during the decade of the 2010s, respectively, in several emerging market economies. The ratio in India turns out to be less than one-third of that in China and only slightly more than one-third of that in Vietnam. It is less than half of that in Thailand and significantly lower than those in Chile and Brazil. The chart in the lower half of Figure 3 shows that India was the only country among those shown with a negative growth in this ratio during the decade of the 2010s. The accumulation of NPAs, which began around 2014–15, seriously dented the ability of banks to expand credit. As a result, credit growth fell behind the nominal GDP growth. Given that banks account for a majority of the commercial financial flows in emerging market economies, this comparison points to a significant scope for increased financialization of the economy in the coming decades.

Banks in India continue to face a high SLR. In addition, the central bank subjects all domestic commercial banks other than regional rural banks, small finance banks and foreign banks with 20 or more branches to "priority

FIGURE 3. Bank Credit as Percent of GDP and Percent Change in It in 2020 over 2010 in Selected Emerging Market Economies





Source: Data for India is from RBI and for other countries from WDI. Both the ratios and percentage-point change in them relate to fiscal years for India and the calendar year for other countries.

sector" lending. Under the regulation, these banks are required to lend a hefty proportion of their credit (currently 40 percent) to priority sectors. As per the current definition, the latter include agriculture, export credit, education, housing, social infrastructure, renewable energy, and micro, small, and medium enterprises (MSMEs). Although SLR has seen a steady decline in the post-reform era, it remains high at 23 percent of all banking assets. This mandatory investment in government securities comes on top of a 4.5 percent Cash Reserve Ratio (CRR) requirement. As regards priority-sector lending, it has seen an increase as a proportion of assets (Table 2). Altogether, SLR, CRR, and priority-sector lending currently absorb 45 percent of the banking assets, leaving only 55 percent to be advanced on purely commercial considerations.

TABLE 2. Mandated Lending and Investments (as Percent of All Assets)

Item	*1997–98*	*2000–01*	*2010–11*	*2020–21*
Priority-sector lending	12.1	11.8	18.3	18.4
Government securities	23.3	27.1	20.2	22.5

Source: RBI statistical tables.

The final indicator we consider before turning to an assessment of banks according to ownership relates to the allocation of credit across broad sectors.[3] Not only is the overall level of bank credit in India low relative to economically successful emerging market economies, but its allocation across sectors is also distorted with the share of industry witnessing a sharp decline in recent years. This share has fallen from 43.9 percent in 2000–01 to 28 percent in 2020–21. Agriculture, which has seen its share in GDP steadily decline to approximately 15 percent, has nevertheless seen a modest expansion in its share in bank credit. This expansion has taken place on top of massive and expanding price subsidies on purchases of fertilizer and sales of foodgrains. The biggest beneficiary of the shift in credit allocation away from industry has, however, been personal loans. From just 12.2 percent in 2000-01, its share in credit has risen to 25.9 percent in 2020–21. Table 3 reports these trends in sectoral shares of the total credit.

TABLE 3. Allocation of Credit across Broad Sectors (Percent of Total Credit): 1997–98 to 2020–21

Sector	*1997–98*	*2000–01*	*2010–11*	*2020–21*
Agriculture	10.7	9.6	11.3	13.7
Industry	48.8	43.9	39.6	28
Personal loans	10.5	12.2	16.4	25.9
Other (mainly services)	30	34.2	32.7	32.3

Source: RBI, Basic Statistical Return (BSR-1) Annual Credit by Scheduled Commercial Banks.

3. Private and Public Sector Banks

The aggregate picture presented up to this point masks the vastly different performances of private and public sector banks (PSBs). These differences form the subject matter of the present section. Occasionally, we also include the remaining banks, consisting of foreign banks, small finance banks, and payments banks though not regional rural banks. Since the largest PSB—the State Bank of India plus its associate banks (SBI)—accounts for more than one-third of all banking assets in the public sector, we also highlight it separately. To economize on space, we limit ourselves to presenting the evidence, letting the graphs speak for themselves, and refrain from a long commentary.

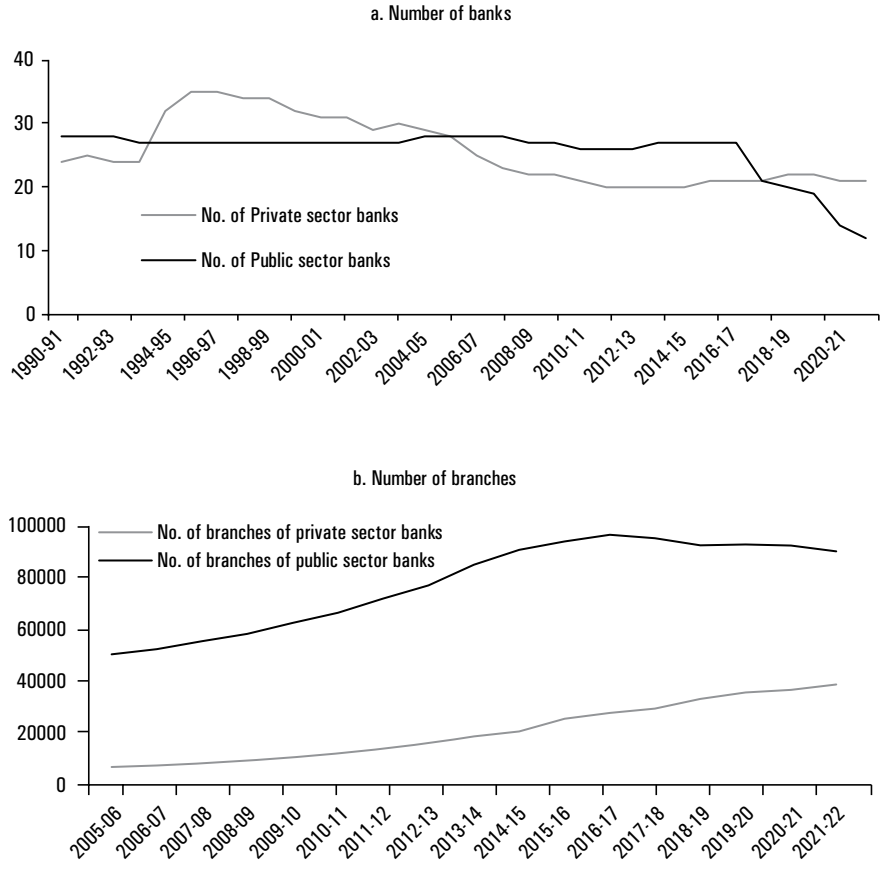
3.1. Number of Banks and Bank Branches

In the upper and lower panels of Figure 4, we show the number of banks and the number of bank branches, respectively, in private and public sector banks. The

3. In the Appendix, we provide figures showing additions to employees, branches, credit growth and deposit growth for PSBs and private banks.

graph indicates some churning in both categories of banks. In 1990–91, there were 24 private banks in all. In view of the small share of private banks in the total banking assets at the time (see below), all these banks were small. Their number grew sharply from 24 in 1993–94 to 32 in 1994–95, and peaked at 35 in 1995–96. It fell steadily thereafter, dropping to 27 in 2002–03, rose to 30 in 2003–04, and began falling again, bottoming out at 20 in 2011–12. In the last decade, this number has seen a very small fluctuation between 20 and 22, and stands at 21 at the end of 2020–21. When the number of banks rises, it is due to the entry of new banks while when it shrinks, it is due to mergers. Banks have rarely been allowed to go bankrupt and exit in India.

FIGURE 4. Number of Private and Public Sector Banks and Bank Branches: 1990–91 to 2021–22



Source: RBI, Bank branch statistics.

While the number of private banks has seen a movement in both directions during the three decades covered, the number of bank branches has seen a steady rise. It stood at 38,772 at the end of 2021–22. This is in contrast to the number of bank branches of PSBs, which has seen a reduction, at least during a handful of previous years.

The evolution of PSBs has been somewhat different from that of private banks. Their number began at 28 in 1990–91, fell to 27 in 1993–94, and stayed there for a decade until 2003–04. It then exhibited small fluctuations between 26 and 28, and stood at 27 in 2016–17. From that point on, considerable consolidation took place through mergers with the number steadily declining to 12. Purely in terms of numbers, there are thus fewer PSBs than private banks today. As noted above, the public sector has also seen some churning in the number of bank branches. The number of PSBs grew steadily to 96,584 by the end of 2016–17, but has since shrunk to 90,160 at the end of 2021–22.

As a side note, we may observe that considering that India has approximately 600,000 villages and the sum of bank branches between private and public sector banks is less than 129,000, it is evident that most villages do not have a bank branch. This conclusion is reinforced by the fact that the number of bank branches is disproportionately high in urban areas. Opening brick and mortar bank branches involves large fixed and recurring costs relative to the economic size of a village, making such a proposition financially and economically unprofitable. This is a lesson that was learned the hard way from the forced expansion of bank branches in the 1980s.[4]

3.2. Banking Assets, Deposits, and Credit

We next consider the shares of different bank groups in banking assets, deposits, and credit. To be exhaustive, we classify all the commercial banks into four categories. The first group is represented by SBI, which includes SBI plus its associated banks.[5] We report the shares of this group separately because it constitutes India's largest bank group and accounts for a disproportionate share of PSBs by all the three measures considered. It is a reasonable hypothesis that being disproportionately large, it behaves differently than the remaining PSBs. We next report the remaining PSBs whose numbers vary over time, as

4. This feature is yet another manifestation of the dispersion of the Indian population over a large number of thinly populated habitations. This dispersion poses many developmental challenges, including in the area of financial inclusion. Unfortunately, the consolidation of population into larger habitation, mainly through migration to urban agglomerations, has been painfully slow. In the banking area, the advent of digital technologies offers some hope but the deposit and withdrawal of cash requires the physical presence of some entity that can intermediate these basic transactions.

5. The associated banks of SBI are: State Bank of Bikaner, State Bank of Jaipur, State Bank of Hyderabad, State Bank of Indore, State Bank of Mysore, State Bank of Patiala, State Bank of Saurashtra, and State Bank of Travancore.

has already been discussed. The third category represents private banks, and the fourth and final one, all other banks. Included in this latter category are foreign banks, small finance banks, regional rural banks, and payments banks.

Table 4 provides the values of shares of the four groups in total banking assets, deposits, and credit at the end of 1991–92, 2000–01, 2010–11, and 2020–21. The indicators now show a much sharper shift away from PSBs and towards private banks. Interestingly, according to all the three measures, the shift in the middle decade is the smallest in percentage-point terms and the largest in the last one. The "boom" that PSBs experienced in the middle decade ended up as a major bust in the last one.

TABLE 4. Shares across Ownership Groups and Credit-Deposit Ratio

Bank Group	*1991–92*	*2000–01*	*2010–11*	*2020–21*
Assets as Percent of Total				
SBI	33.8	31.1	22.2	23.1
Other Public Banks	54.7	48.4	51.5	36.7
Private Banks	4.2	12.6	19.5	32.8
All Others	7.4	7.9	6.8	7.3
Credit to Private Sector				
SBI	32.2	27.6	23.6	22.4
Other Public Banks	57.8	49.1	51.7	34.1
Private Banks	4	13.9	19.8	38.1
All Others	5.9	9.4	4.9	5.4
Deposits as Percent of Total				
SBI	28.6	29.6	22.2	23.6
Other Public banks	60.3	51.9	55.7	39.8
Private Banks	4.6	13	17.9	30.8
All Others	6.5	5.6	4.3	5.8
Credit-Deposit Ratio				
SBI	0.71	0.48	0.80	0.67
Other PSBs	0.56	0.48	0.74	0.63
Private	0.52	0.50	0.80	0.82

Source: RBI, Statistical tables relating to banks in India (Tables based on Annual Accounts).

Turning to the specific indicators, PSBs (including SBI) began with an 88.5 percent share in the total banking assets in 1991–92, and private banks began with just 4.2 percent. But by 2020–21, the share of PSBs had fallen to 59.8 percent and that of private banks had risen to 32.8 percent. In the "All Others" category, foreign banks account for the bulk of the assets. In 2020–21, small

finance banks accounted for 0.8 percent of all banking assets and payments banks for just 0.06 percent.

When compared to the telecommunications sector in which private entry was permitted for the first time in the early 1990s, the impact of entry liberalization in the banking sector around the same time appears modest. While PSBs as a group continue to be the dominant player in banking, the State operator has been left with a minuscule share in telecommunications. The infusion of large volumes of resources into PSBs by the State has meant much slower progress of private sector banks in expanding their share in banking.

The ownership of assets behaved quite differently between the decades of the 2000s and 2010s within the PSBs. SBI experienced a major loss in its asset share in the former decade but made a marginal gain in the latter one. Exactly the opposite turned out to be the case for the other PSBs: they experienced a marginal gain in the asset share in the 2000s but a major loss in the 2010s.

The story observed in terms of assets is broadly mirrored in the behavior of credit and deposits. Private banks have steadily increased their shares in credit as well as deposits during the three decades. The share in credit rose from just 4 percent in 1991–92 to 38.1 percent in 2020–21. The share in deposits rose from 4.6 percent to 30.8 percent over the same period. Nearly all of the corresponding decline fell on PSBs with SBI bearing the larger burden in the 2000s, and the other PSBs in the 2010s. An interesting point to note is that the share of private banks in credit rose faster than that in deposits.

The final set of numbers in Table 4 report the credit-deposit ratios for SBI, other PSBs, and private banks. Private banks were lagging behind PSBs in 1991–92, kept pace with or did marginally better than them in 2000–01 and 2010–11, and then pulled ahead of them by a significant margin in 2020–21. According to the GlobalEconomy.com ranking of countries by the credit-deposit ratio, India was ranked 77th globally in 2020. As many as 27 countries in this ranking exhibit credit-deposit ratios exceeding unity.[6] Therefore, there remains considerable scope for credit expansion in India even with the existing deposits. Even private banks are some distance from exploiting their full capacity to expand credit. It goes without saying, however, that unlike what was done during several years preceding 2014–15, credit must now go to worthy borrowers.

The patterns exhibited by the three indicators can also be gleaned from the growth rates during the relevant decades (Table 5). Based on data availability, this table replaces "Other Banks" in Table 4 by all Scheduled Commercial Banks (SCBs). Consistent with Table 4, the growth rates for assets, advances, and deposits for private banks have been consistently higher than those for SBI as well as other PSBs. Between SBI and the other PSBs, the latter showed higher growth rates in the 2000s and the former in the 2010s. The conclusion

6. See https://www.theglobaleconomy.com/rankings/bank_credit_to_deposits/ (accessed June 4, 2022).

that these indicators point to superior performance of private banks, especially when seen against the amounts of capital infused by the government in PSBs over the years, is inescapable.

TABLE 5. Average Annual Growth Rates (All Nominal)

Bank Group	*1990–2000*	*2000–2010*	*2010–2020*
Assets			
SBI	13.3	15.6	10.9
Other PSBs	13.1	18.6	8.7
Private Banks	31.7	24.6	17.7
Scheduled Commercial Banks	14.6	18.5	11.6
Advances			
SBI	11.7	21.1	10.6
Other PSBs	11.9	23.7	8
Private Banks	31.4	28.5	19.2
Scheduled Commercial Banks	13.6	23.1	11.6
Deposits			
SBI	16.4	16	11.4
Other PSBs	14.3	18.4	8.7
Private Banks	32	22.1	17.7
Scheduled Commercial Banks	16.3	18.1	11.5

Source: RBI, Statistical tables relating to banks in India (Tables based on Annual Accounts).

3.3. Credit Allocation

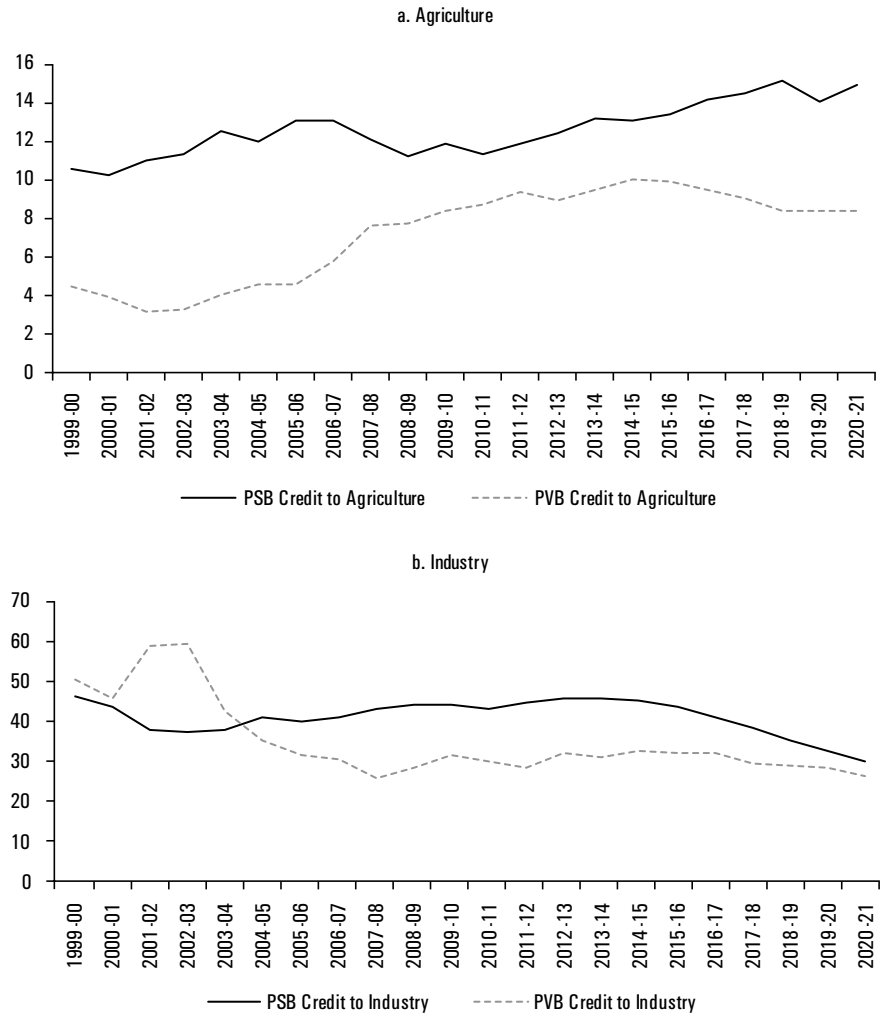
As Figure 5 shows, PSBs and private banks (PVBs) allocate credit across broad sectors quite differently. PSBs have consistently allocated a larger proportion of their total credit to agriculture than have PVBs. With the exception of the first half of the 2000s, they have also allocated a larger share of their total credit to industry than PVBs. Private banks, on the other hand, have been focused more on personal loans and all other categories. Although priority sector minimum is fixed at 40 percent of adjusted net bank credit for both private and public sector banks, it is possible that the latter are subject to additional informal government pressure or direction to lend higher proportions of their credit to agriculture and industry. If so, this is an additional source of distortion in lending by PSBs.[7]

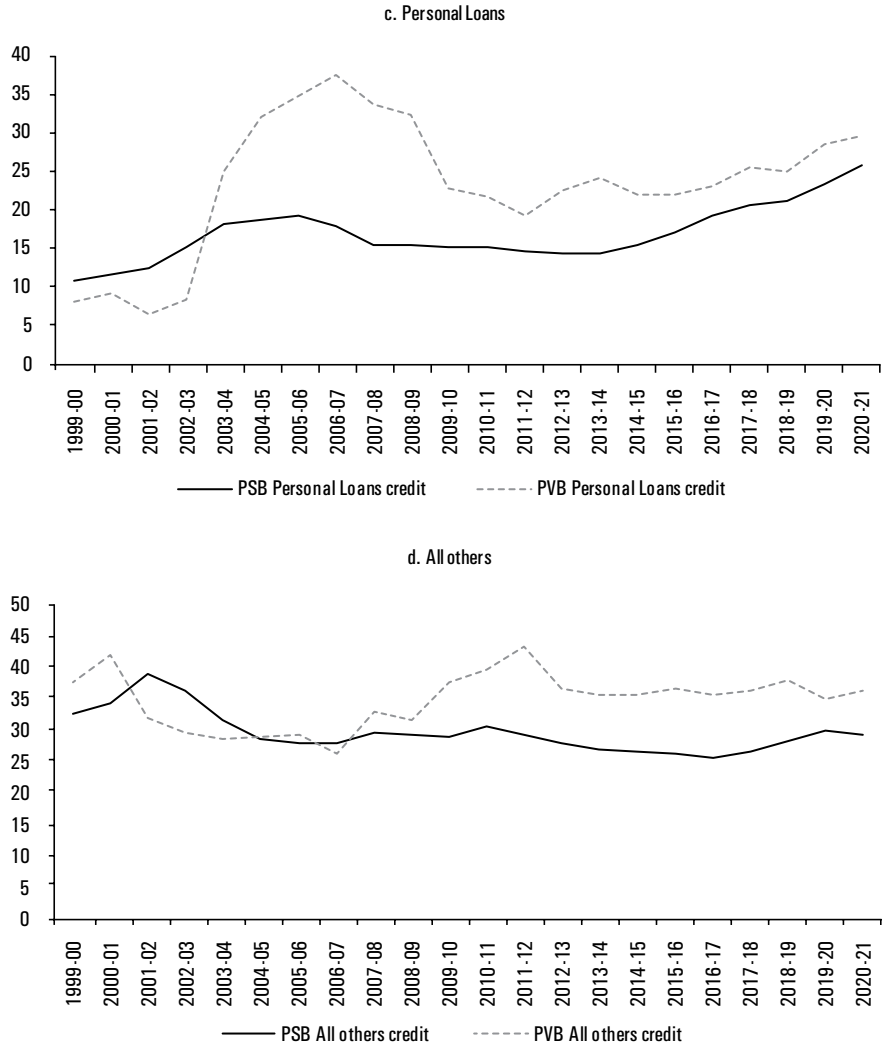
7. George et al. (2022) analyze the link between productivity and bank credit growth across public and private sector banks. They find this link to be weaker for public sector banks. In other words, public sector banks do not extend credit to most productive firms. The implication is that there are potential growth and productivity gains to be made from improved governance or privatization of public sector banks.

3.4. The Dramatic Shift into Private Banks in the Past Five Years

Shifts in shares based on the "stock" variables such as assets, deposits, and advances discussed up to this point greatly understate the pace at which the shift away from PSBs and towards private banks has taken place in recent years. To fully appreciate the dramatic shift that has taken place, we must look at the shares in the "flow" variables. Accordingly, Figure 6 shows the shares of SBI, other PSBs, and private banks in the increases in advances and deposits from 2014–15 to 2020–21. Remarkably, private banks accounted for 68.6 percent

FIGURE 5. Allocation of Credit by PSBs and PVBs across Broad Sectors of the Economy



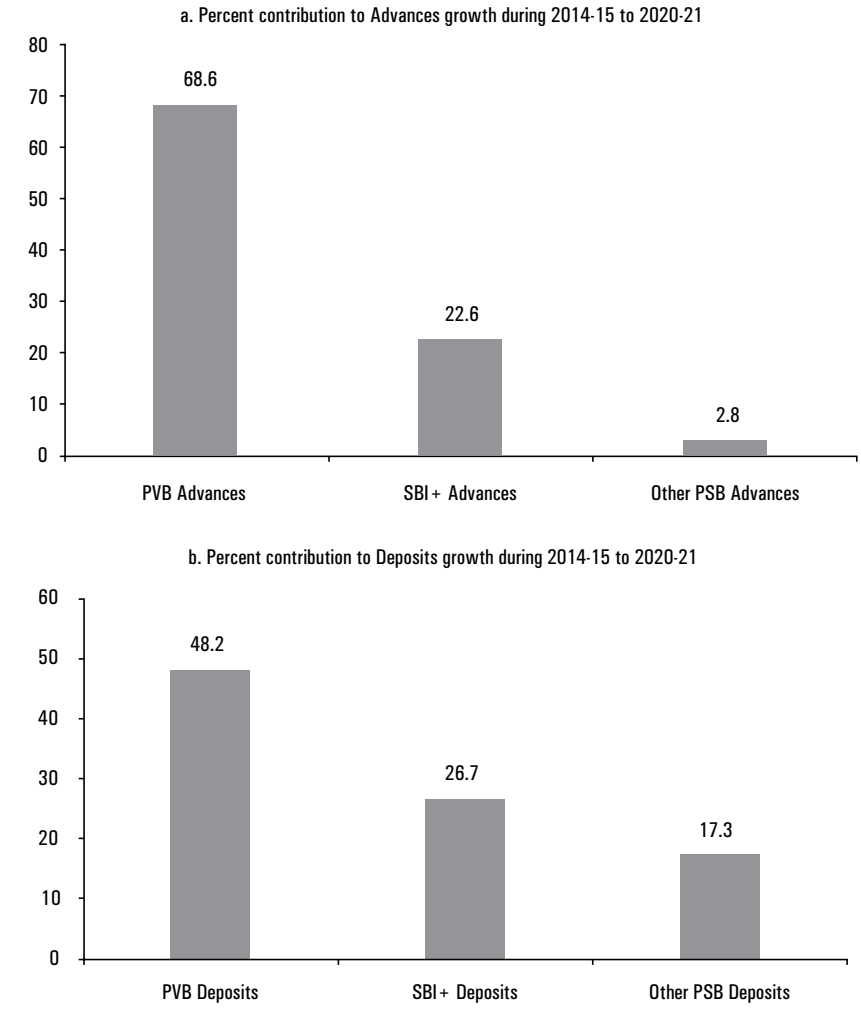


Source: RBI, Basic Statistical Return (BSR-1) Annual Credit by Scheduled Commercial Banks.

of all additional credit created during these years. Despite their large volume of assets and deposits, PSBs other than SBI contributed just 2.8 percent of the additional credit creation.[8] The same, though a little less dramatic, pattern emerges from the shares in the change in deposits over these years: private banks accounted for 48.2 percent of the new deposits.

8. The shares shown in Figure 6 do not add up to 100 percent because of the exclusion of foreign, small finance, and payments banks.

FIGURE 6. Shares in the New Advances and Deposits by Bank Groups: 2014–15 to 2020–21

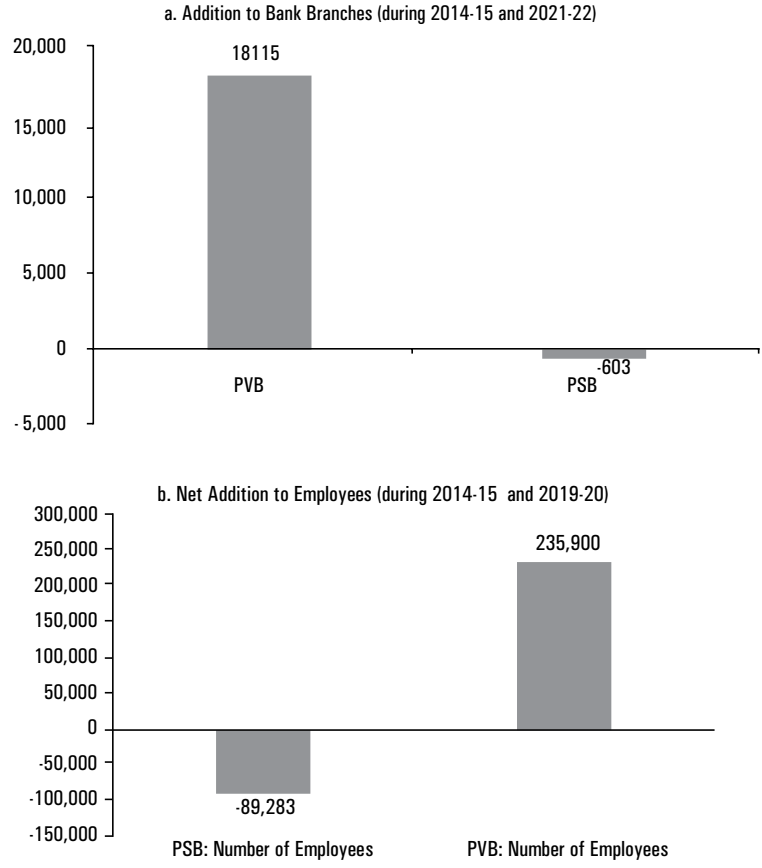


Source: RBI, Statistical tables relating to banks in India (Tables based on Annual Accounts).

A common impression among policy analysts is that PSBs constitute an important source of well-paid jobs whereas private banks rely more heavily on automation including digitization. Yet, when we look at the changes that have taken place in the workforces of PSBs and private banks, it is the latter that have served as the source of job creation. Between 2014–15 and 2019–20, private banks created 235,900 new jobs while PSBs experienced a net loss of 89,283 jobs. The same point is also made by bank branch expansion: whereas PSBs closed down 603 branches on a net basis, private banks added 18,115 of them (Figure 7).

To be sure, the loss of jobs and bank branches in PSBs represents a healthy development since historically they have employed far more workers and opened more branches relative to their assets, advances, and deposits than private banks. The point we want to underline here is that as private banks expand, they too create jobs and bank branches. Indeed, if the dynamism of private banks leads to greater overall expansion of the banking sector, they can add more jobs and bank branches even if due to higher efficiency they employ fewer workers and open fewer branches per billion rupees worth of advances or deposits.

FIGURE 7. The Change in Employment and Bank Branches in PSBs and Private Banks

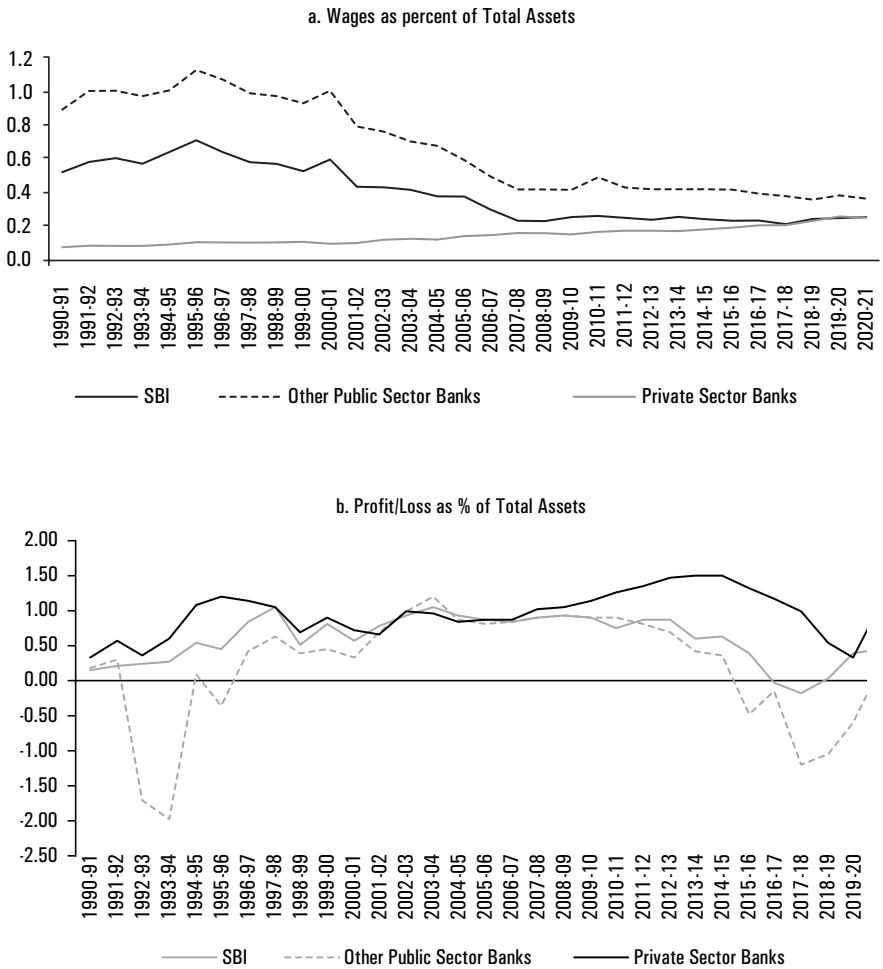


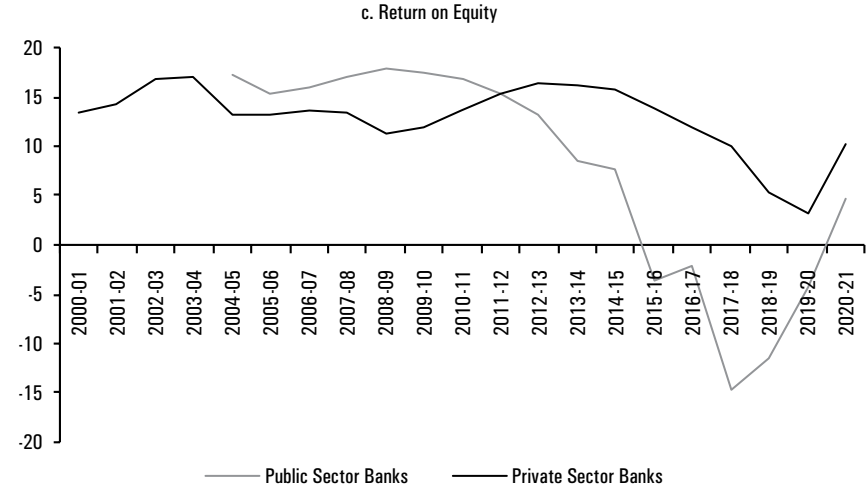
Source: RBI, Handbook of Statistics on Indian Economy, Money and Banking, Bank Group-wise distribution of Employees of Scheduled Commercial Banks.

3.5. Some Performance Indicators

Private banks have exhibited superior performance, especially in recent years, across a number of indicators, such as the wage bill as a percentage of the total assets, profits as a percentage of the total assets, and return on equity. Within PSBs, SBI generally performs better than the other PSBs. The trends in these measures during the past two or three decades for the three bank groups are shown in Figure 8.

FIGURE 8. Some Performance Indicators for Private and Public Sector Banks





Source: Authors' calculation and RBI statistical tables.

3.6. Non-performing Assets, Stressed Assets, and Provision Coverage

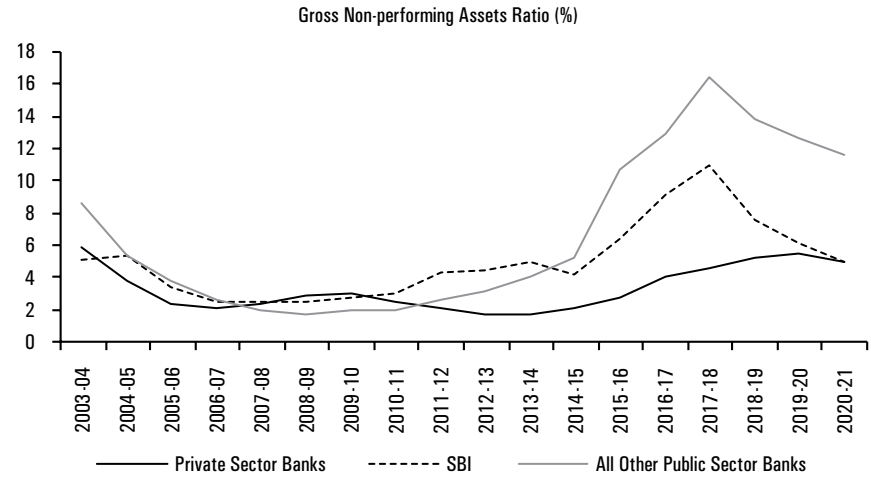
India first introduced a "health code" in 1985 requiring banks to classify each loan into one of eight categories based on its performance. Classification into the bottom four of these categories meant that the loan was non-performing. In 1992, this classification was replaced by a more demanding one which required each loan to be classified into one of four categories: standard, sub-standard, doubtful, and loss. All loans in the last three categories were considered as non-performing. Over time, the criteria for defining healthy loans were tightened further and got aligned with international norms in 2004. Accordingly, a delay of 90 days in payment places it into the non-performing category with a sub-standard status. After one year of substandard status, it becomes doubtful. If the loan becomes substantially uncollectable, it is given a loss classification. A substandard loan requires provisioning of 10 percent of loan value. Once it turns doubtful, the required provisioning rises to 100 percent for the unsecured part of the loan and 20 to 50 percent for the secured portion.

Figure 9 shows the gross NPAs as a percent of gross advances of SBI, other PSBs, and private banks.[9] For more than a decade, the RBI had permitted loans to be restructured without a downgrade in their classification. This meant that if a borrower anticipated difficulty in repaying the loan, she could ask the lender

9. Mohan and Ray (2022) have documented and analyzed the trajectory of NPAs since the early 1990s. They attribute the rise in NPAs during the last decade to a host of factors, such as commodity prices, business cycle, and regulatory forbearance, with governance issues in PSBs being one of them. They suggest that policy initiatives like bankruptcy reforms would lower the NPA of Indian banks durably.

to restructure it at more favorable terms. For the lender, the choice was between a default, which would weaken the balance sheet, and restructuring, which would not. Given the state of the bankruptcy process, recovery was difficult and uncertain even in cases in which the borrower's enterprise became unviable. An additional factor at work in PSBs was that their CEOs were government employees appointed for limited terms. Therefore, the CEO's incentives were to restructure doubtful loans and maintain their standard classification while they served even if it was clear that the loans had no chance of being repaid. In contrast, the managers of private banks remained answerable to their boards and shareholders, which translated into more responsible lending and restraint on restructuring doubtful loans.

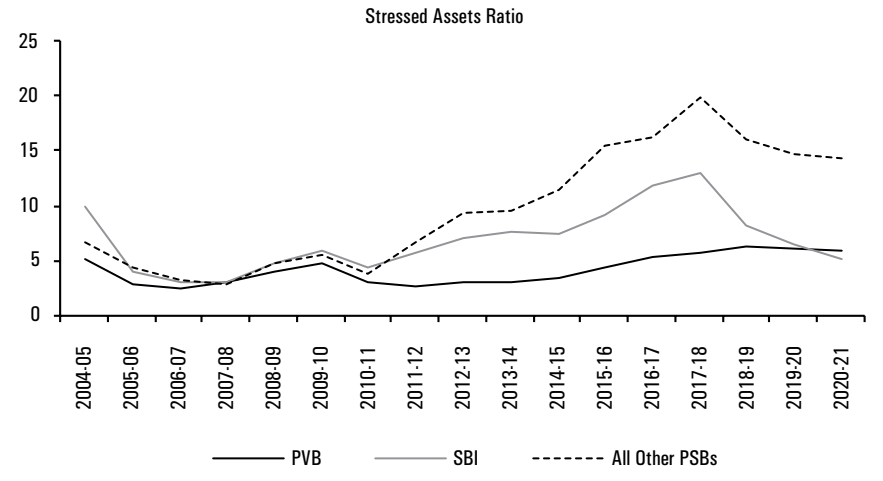
FIGURE 9. Gross NPAs as a Proportion of Gross Advances: 2003–04 to 2020–21



Source: RBI statistical tables.

It was beginning with the year 2015–16 that the RBI finally changed the policy and started mandating downgrading of loan classification upon restructuring. The change quickly led to the recognition of vast volumes of loans as non-performing. It can be seen that the problem turned out to be far more serious in PSBs than in private banks. SBI incurred smaller NPAs than other PSBs but still significantly larger than private banks. This most likely reflects better management at SBI than other PSBs but also closer scrutiny of it by the government, given its large size. The systemic risks of SBI losing creditworthiness are far larger than any one of the smaller PSBs. An interesting feature of Figure 9 is that whereas the NPAs of PSBs peaked in 2017–18 and began declining thereafter, the NPAs of private banks, though smaller, rose until 2019–20 before seeing a modest decline in 2020–21.

FIGURE 10. Stressed Assets as a Proportion of Gross Advances for Bank Groups: 2005 to 2021



Source: RBI, statistical tables relating to banks in India.
Note: Stressed Assets Ratio is defined as (Gross NPA + Restructured Loans)/Gross Advances.

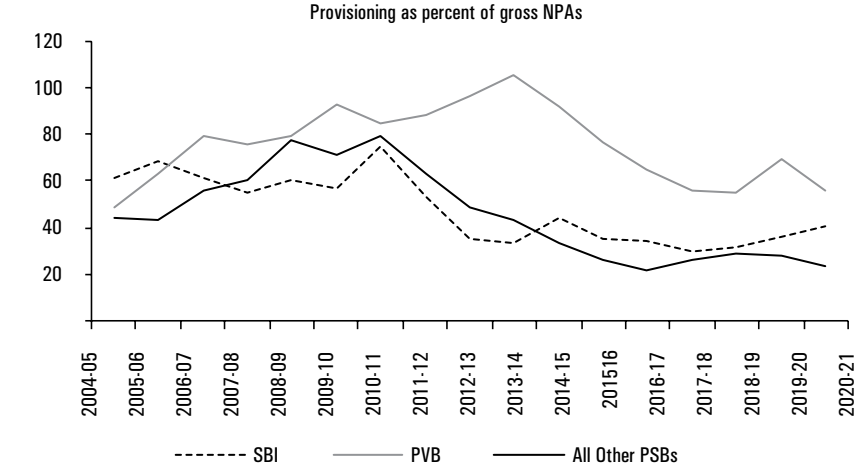
Two other indicators reinforce the observation of the superior performance of private banks, followed by SBI, and other PSBs, in that order. In Figure 10, we depict the stressed asset ratio, which measures gross NPAs plus restructured standard advances as proportions of total advances. It is evident that beginning with 2011, stressed assets had begun to spike as the problem remained unaddressed until it became much bigger.

Finally, Figure 11 shows provisioning plus contingencies as a proportion of the gross NPAs for the three categories of banks. This measure also shows the superior performance of private banks, followed by SBI, and other PSBs, in that order, at least in the more recent years. Private banks have consistently maintained higher levels of provisions relative to NPAs than their public sector counterparts.

3.7. Bank Frauds

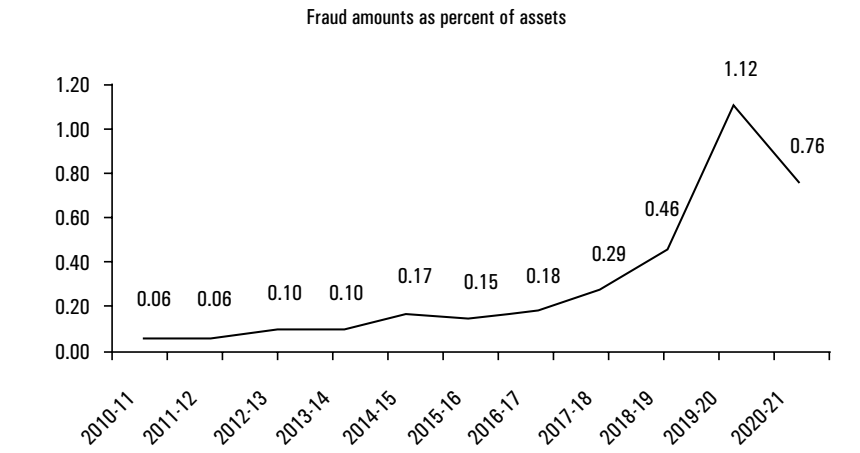
Bank frauds, which include misappropriation, fraudulent encashment, unauthorized credit, and fraudulent foreign-exchange transactions, have seen an uptick in recent years not only in absolute terms but even relative to assets. At an aggregate level, they steadily rose from 0.06 percent of combined assets of SBI, other PSBs, and private banks to the peak of 1.12 percent in 2019–20, before declining to 0.76 percent in 2020–21. Figure 12 depicts the evolution of frauds as a percent of the assets at the aggregate level. In recent years, there have been some high-profile cases of fraud contributing to large amounts. Evidently, they partially reflect a failure of the regulator in catching wrongdoings on time.

FIGURE 11. Provisions and Contingencies as Percent of Gross NPAs: 2004–05 to 2020–21



Source: RBI, Statistical tables relating to banks in India (Provisions and contingencies of Scheduled Commercial Banks).

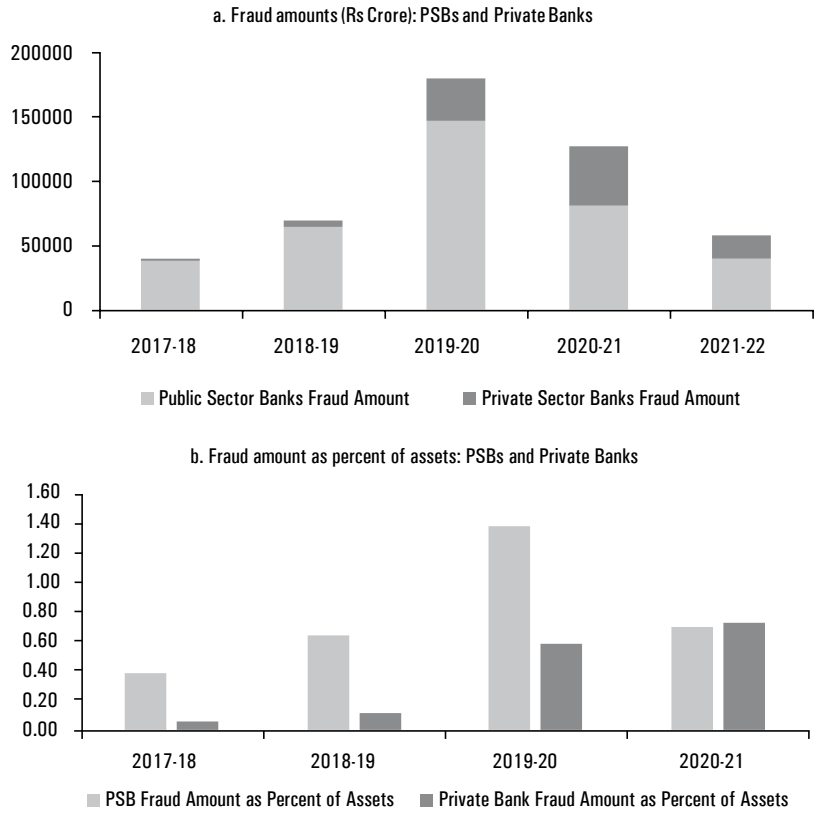
FIGURE 12. Bank Fraud as a Percent of Combined Assets of SBI, Other PSBs, and Private Banks



Source: Compiled from RBI Annual Reports.

From 2017–18 onwards, we also have the disaggregation of fraud amounts between PSBs and private banks. These disaggregated data show that fraud amounts have concentrated disproportionately in PSBs. In Figure 13, the upper panel shows the split of fraud amounts between PSBs and private banks, while the lower panel shows fraud amounts as proportions of assets for the two categories of banks.

FIGURE 13. Fraud Amounts in PSBs and Private Banks: 2017–18 to 2020–21



Source: RBI Annual Reports.

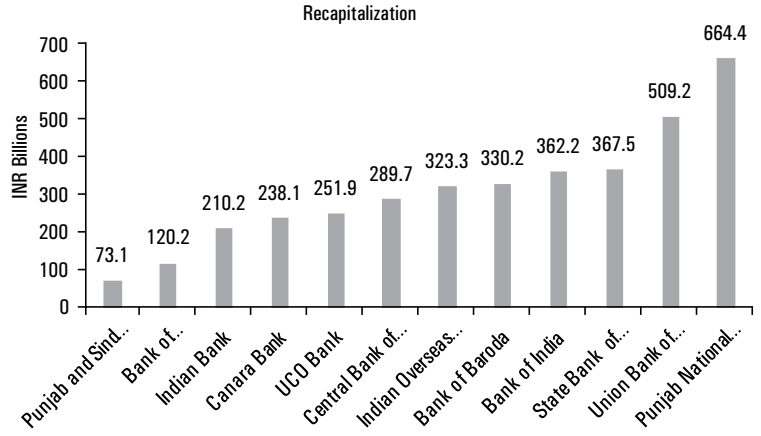
3.8. Infusion of Capital and Market Valuation

Evidence presented up to this point already overwhelmingly speaks to the superior performance of private banks over PSBs. Even SBI, which has performed better than other PSBs in the decade of the 2010s, fails to match the performance of private banks, on average, in terms of nearly all indicators. But as a last and final piece of evidence, we turn to a consideration of taxpayer resources that the government was obliged to infuse into them through recapitalization. The sheer magnitude of these resources is breathtaking.[10] In contrast, no taxpayer resources were infused into private banks though in one visible case, that of

10. Chopra et al. (2021) argue that recapitalization policies are necessary after a clean-up even during normal times. They reason that the assumption that reduction in information asymmetry after the clean-up will lead to recapitalization through market forces alone is questionable.

Yes Bank, the government did have to intervene with a heavy hand through a consortium led by SBI and including a number of private banks. The experience of this bank, discussed in brief at the end of this section, has useful lessons. We depict this stark fact in Figure 14, which shows the amount of taxpayer money spent on recapitalization of each of the 12 PSBs from 2010–11 to 2020–21.[11]

FIGURE 14. Taxpayer Resources Infused into 12 PSBs



Source: Credit Suisse.

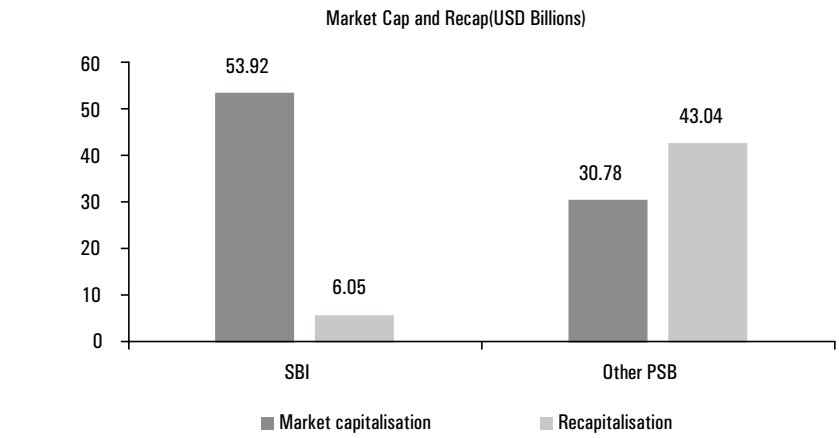
In dollar terms, the total amount infused into PSBs between 2010–11 and 2020–21 to help them tide over the NPA crisis stands at $57.45 billion.[12] Of this amount, $6.05 billion went to SBI and $51.40 billion to other PSBs. Even after this massive infusion, the NPAs of PSBs taken as a whole remain elevated relative to private banks. Only the NPAs of SBI have come down to the same level as their average level across all private banks in the year 2020–21.

11. In its audit report on recapitalization, the Comptroller and Auditor General of India (2017) states: "PSBs signed (February/March 2012) MoUs with DFS [Department of Financial Services] for performance linked capital infusion in PSBs during 2011–12 to 2014–15. However, achievement against MoU targets was not linked to actual capital infusion." We may add that under Indradhanush, PSBs were to raise capital from the market to the tune of Rs 1.1 trillion between 2015–16 and 2018–19. But only a small fraction of this amount (Rs 77.26 billion between January 2015 and March 2017) was actually raised.

12. The original amounts of recapitalization are available in rupees by the financial year. We have converted these rupee amounts into dollars using the average exchange rate during the financial year by RBI. We thank Mr Neelkanth Mishra, Credit Suisse, for sharing these data with us. The total amount reported in the text, $57.45 billion, excludes $8.21 billion infused into IDBI Bank by its owner Life Insurance Corporation (LIC) Ltd, India's largest public sector enterprise by assets. For now, the burden of this amount has not fallen on the taxpayer but this may change if LIC itself has to be recapitalized by the government at some point.

What is more striking, however, is that in the case of PSBs other than SBI, the current market valuation (as on 31 May 2022) remains significantly below the recapitalization resources infused into them. This is shown in Figure 15. At the end of May 2022, the market valuation of PSBs other than SBI and IDBI Bank was just $30.78 billion. In comparison, these banks had received a massive $43.04 billion in capital infusion.[13]

FIGURE 15. Recapitalization and Market Capitalization

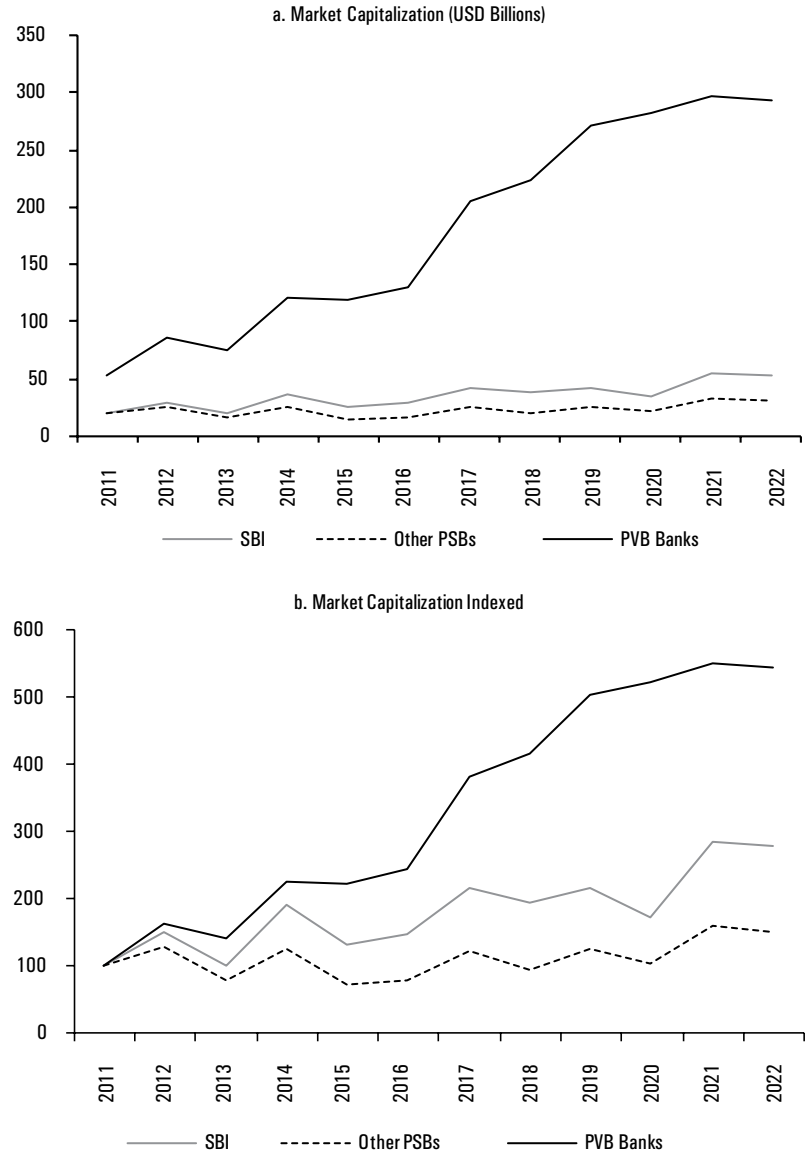


Source: Credit Suisse and Companiesmarketcap.com.

Two further points relating to market valuation are worth making. First, despite their much smaller share in assets, private banks have left behind PSBs by miles in market valuation. This is underlined in Figure 16, which shows the market valuations of the three categories of banks from 2011 to 2022. The chart in the upper half shows the evolution in dollar terms and that in the lower half in terms of the indexed value with the valuation of each category of banks set at 100 in 2011. The difference in performance between PSBs and private banks is striking. Even SBI, which has exhibited respectable if not spectacular performance in terms of most other indicators, fails to come even close to the performance of private sector banks.

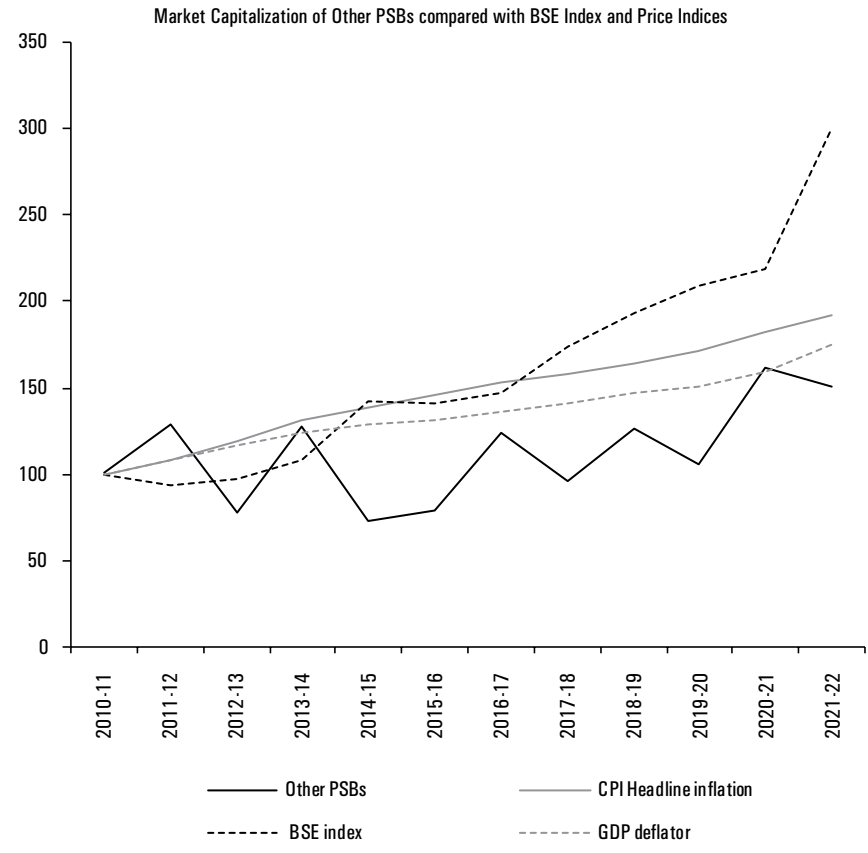
13. In the data series on market valuation, we could access from a single source, UCO Bank and Central Bank of India were missing. As a result, they are not included in "Other PSBs" in Figure 15. The amount of capital infused into "Other PSB" banks shown in the figure ($43.04 billion) excludes the amounts infused into these two PSBs.

FIGURE 16. Market Valuation of SBI, Other PSBs and Private Banks



Source: Companiesmarketcap.com, accessed May 31, 2022.

FIGURE 17. Market Valuation of PSBs other than SBI Compared to the BSI Index, CPI, and GDP Deflator



Source: Companiesmarketcap.com, RBI and MoSPI.

Second, the performance of PSBs other than SBI in terms of market valuation throughout 2010–11 to 2021–22 has been depressingly poor. It is not only the Bombay Stock Exchange (BSE) index that has left the progress in their valuation far behind, but even the GDP deflator which moves up extremely slowly has been ahead of them. Figure 17 compares the evolution of the market valuation of these banks with the BSE index, GDP deflator, and the Consumer Price Index.

While no taxpayer money has had to be deployed to recapitalize private banks, the government did have to intervene with a heavy hand to rescue Yes Bank. Questionable lending and lack of transparency in identifying NPAs considerably weakened the bank's balance sheet by the end of 2016, but it went unnoticed by the market at least until September 2018. From that point on, the

condition of the bank deteriorated steadily, culminating in a situation wherein the government had to place the bank under a moratorium on 5 March 2020 and announce a scheme of reconstruction on 6 March 2020. As a part of the scheme, the government pressed SBI into acquiring a 48.21 percent stake in Yes Bank, paying a price of Rs 10 for shares with face value of Rs 2 only.[14] Additionally, the government leaned on HDFC Bank, ICICI Bank, Axis Bank, Kotak Mahindra Bank, Bandhan Bank, and Federal Bank to buy additional stakes, adding up to a 30 percent equity at the same share price. All the banks also had to agree to lock-in 75 percent of the equity for three years.

As on 7 June 2022, the shares of Yes Bank were trading at Rs 13.1 per share. While the participant banks are thus likely to be able to recover their investment with a positive return, it is unlikely that they would have invested their capital voluntarily in the bank. To be sure, the rescue was in the joint interest of all banks since the failure of Yes Bank would have adversely impacted their own valuations. Nevertheless, the free-rider problem meant that individual banks would not have come forward to invest in the rescue voluntarily.

4. Privatization: Why?

The case for privatization is largely based on the evidence of superior performance of private banks relative to PSBs that we have presented in the previous section.[15] But a number of additional points must be considered to strengthen the case and address potential criticisms.

4.1. PSBs and Stability of the Banking Sector during a Financial Crisis

During the 2008 financial crisis, some observers had argued that with PSBs dominating, India's banking sector was able to weather the crisis better than other countries. The argument was based on the observations that in the immediate aftermath of the crisis, private banks found their valuations to decline much more sharply than PSBs and depositors exhibited a tendency to switch out of private banks and into PSBs. One major private bank even experienced a mini-crisis as a result of this shift with the result that the RBI had to intervene on its behalf to reassure depositors.

At least two studies have subjected this argument to empirical scrutiny and concluded against its validity. Acharya (2012) found that the smaller

14. The then chair of SBI, Rajnish Kumar, has written in his book, *The Custodian of Trust*, that his bank was reluctant to play the role of the lender of the last resort but was compelled to do so.

15. La porta et al. (2002) is among the first papers which attributed slow financial development and low growth of per capita income and productivity to the State ownership of banks. The paper also showed that the government ownership of banks is large and pervasive in countries with low levels of per capita income and backward financial systems.

decline in valuation of PSBs and the movement of depositors towards PSBs principally reflected a stronger implicit guarantee on deposits held in them. He characterized this asymmetry as a distortion that tilted the playing field in favor of PSBs, especially in times of financial crises. Eichengreen and Gupta (2013) reached much the same conclusion, stating, "While there was some tendency for depositors to favor healthier banks and banks with more stable funding, the reallocation of deposits toward the State Bank of India cannot be explained by these factors alone. Rather it appears that the implicit government guarantee of the liabilities of the country's largest public bank dominated other considerations." The authors note that rather than playing a stabilizing role, the stronger implicit guarantee on PSB deposits may have contributed to the destabilization of some private banks, most notably ICICI Bank.

Longer-term trend in deposits reinforces the proposition that the movements in them towards PSBs in the aftermath of the financial crisis resulted from a stronger implicit guarantee by the government. Between 2010–11 and 2020–21, the share of private banks in total deposits rose from 17.9 percent to 30.8 percent. SBI, which has performed significantly better than other PSBs during this decade in terms of most of the indicators considered in the previous section, was able to marginally increase its share as well. But the latter, which fared poorly during the decade, lost share by a massive 16 percentage points.

4.2. Social Objectives

A common defense of PSBs has been that they help the government promote certain social objectives. Indeed, this was the original reason cited for the broad-based nationalization of banks in 1969. At the time, there had been a debate as to whether social objectives could not be pursued through social control with ownership. But post-nationalization, this alternative got largely wiped out from public memory and it became an accepted doctrine that ownership was essential if the government were to promote social objectives such as increased share of agriculture and MSMEs in credit and expansion of banking in rural areas. In more recent times, the ownership argument has also been made in the context of financial inclusion through the rapid expansion of Jan Dhan bank accounts and assistance to firms to tide over the difficult COVID crisis years.

Experience with priority sector lending shows that ownership is not necessary to implement social objectives. Ensuring the availability of credit to certain sectors was perhaps the most important objective cited at the time of the 1969 nationalization. But private banks have been subject to this mandate as much as PSBs almost since the RBI formally began implementing it. Data show full compliance with the 40 percent priority-sector lending directive by private banks.

Generalizing from this experience, it stands to reason that any social objectives should be pursued via regulation rather than ownership of banks. There is hardly

any social goal related to financial intermediation that the government cannot pursue without ownership of banks. On the contrary, government ownership over the years has resulted in a high cost of lending and even impeded progress in the spread of banking. It is a plausible proposition that had the ownership been largely private, India would not have faced the acute NPA crisis that it did in recent years. And absent such a crisis, not only would deposits and credits have seen greater expansion, but the economic performance would also have been superior.

Going one step further, it stands to reason that as long as a large number of banks remain in the public sector, the government will find it hard to resist using them to pursue goals that are best pursued by using alternative instruments. In the past, the government has used PSBs as instruments of employment as well as subsidies to favored actors in the economy through cheaper credit, including outright write-offs of loans. A recent example is the call by the Finance Ministry to PSBs and State-run insurers to explore employment opportunities for youngsters who would be looking for jobs after completing their four-year service in military under the newly launched "Agniveer" scheme. Such mismatch between goals and policies is not only highly inefficient but also has an adverse effect on the growth of banking.

4.3. Governance Issues

Government ownership of banks gives rise to many governance issues bearing on both the efficiency of bank operations and the ability of RBI to regulate the sector. First, loan officers going all the way up to the CEO are subject to strict anti-corruption laws, which may be invoked when bank loans, even when made in good faith, go bad. At the same time, they can expect no real rewards for the superior performance of loans that they extend and the contribution they make to the growth of their bank. This incentive structure discourages them not just from innovation in lending but also any deviation from established practice. A study by Banerjee et al. (2004) found that in most cases, loan officers simply re-approved the previous year's limit on the loan available to a firm. The study also found that corruption charges against an officer in a bank had an immediate chilling effect on lending by other officers in the bank.

Second, PSBs broadly follow the government salary and benefits structure and rules of employment. This has translated into high salaries, benefits, and job protection at the clerical and lower levels but low salaries and benefits at the higher levels relative to those prevailing in private banks.[16] The end result

16. Among PSBs, Canara Bank paid its CEO the highest salary in 2019–20 at Rs 3.92 million. Among private banks, the highest salary the same financial year, at Rs 189.2 million, went to the HDFC Bank CEO. Among the private banks for which salary figures are available, even the lowest CEO salary, at Rs 5.18 million for Tamil Merchant Bank in 2019–20, exceeds that paid by Canara Bank to its CEO.

has been low productivity all around. A high degree of protection against layoffs and lack of a relationship between individual performance and salary increases have made lower-level staff unwilling to perform. And lower salaries of higher-level staff have meant that the banks are unable to attract skilled and high-caliber staff, which is particularly damaging to productivity in the current environment of rapidly changing technology. This factor is very likely behind the poor performance of PSBs and the steady defection of depositors to private banks despite perceptions of lower security of deposits there. The lack of talented staff at upper levels, coupled with resistance to change at lower levels, has also translated into slow modernization of processes including digitization. One fallout of this set of problems has been that some bank frauds that recently came to light had gone undetected for years.

Third, government ownership also brings with it political interference. This interference can come at two levels. The flow of loans may be manipulated to serve political objectives. For instance, Cole (2009) shows that PSBs in India are subject to political capture. Politicians use them to achieve electoral goals through an expansion in lending just prior to elections and targeting of credit to the swing States. He further finds that the marginal political loan is less likely to be repaid than loans extended in normal times.[17] The second form that political interference takes is through the manipulation of specific loans to favored clients. There is a widespread belief that such interference played an important role in the eventual accumulation of NPAs in the second half of 2010s in India. More concretely, using a loan-level dataset of 90,000 firms from Pakistan, Khwaja and Mian (2005) show that firms with directors or executives with political ties borrow 45 percent more and have 50 percent higher default rates. Remarkably, this preferential treatment occurs exclusively in PSBs with no similar favors bestowed by private banks.

In this context, it may be noted that questionable lending is not the exclusive preserve of PSBs. We described earlier the case of Yes Bank, which had to be rescued by the government. But two important points must be recognized in this context. First, the scope for such lending is much greater and such cases much more frequent in PSBs than private banks. Commercial pressures and the need for maintaining reputation work as deterrents to reckless lending in the private sector. Second, the regulator has far more power over private banks than PSBs.

The final point is that government ownership of a subset of banks gives rise to several regulatory problems. One, PSBs themselves end up with two masters: in some areas, they must follow RBI regulation while in others, they

17. Kumar (2020) analyzes the impact of the State elections in India on bank lending and finds strong evidence of politically motivated bank lending to farmers before elections; and that such lending crowds out lending to manufacturing firms. He also provides evidence to support the hypothesis that "such politically motivated increased agricultural lending before State elections contributed towards excessive indebtedness of farmers and a subsequent costly bailout in 2008."

are subject to government-imposed regulations. Two, RBI itself ends up with dual regulation: one set of regulations applies to private banks and another set to PSBs. And three, the government ends up assuming the roles of owner, regulator, and policymaker in banking.

The first problem manifests itself in central government circulars with directives that apply to PSBs but not private banks. For instance, when the government launched the Jan Dhan bank account program, it issued special directives to PSBs that did not apply to private banks. Recently, the government has also set informal loan targets for managers of PSBs, something it is forbidden to do for private banks. The second problem turns out to be even more serious. For instance, RBI can remove directors or the management of private banks but not PSBs. This feature substantively erodes the authority of RBI to regulate PSBs. Finally, the last problem leads to a three-way conflict of interest among the government's role as the owner of PSBs, as regulator and as policymaker. A general best practice rule is for the government to play the role of policymaker only, leaving even regulation to a statutorily independent entity.[18]

4.4. Reform without Change of Ownership?

The case for privatization will remain incomplete without addressing two further questions: (i) Can measures such as prompt corrective action (PCA) and recapitalization be counted on to fix the problem, returning PSBs to good health; and (ii) Even if the answer to the first question is in the affirmative is there a path to reform that would place PSBs on the road to self-sustained healthy growth without transfer of ownership to the private sector?

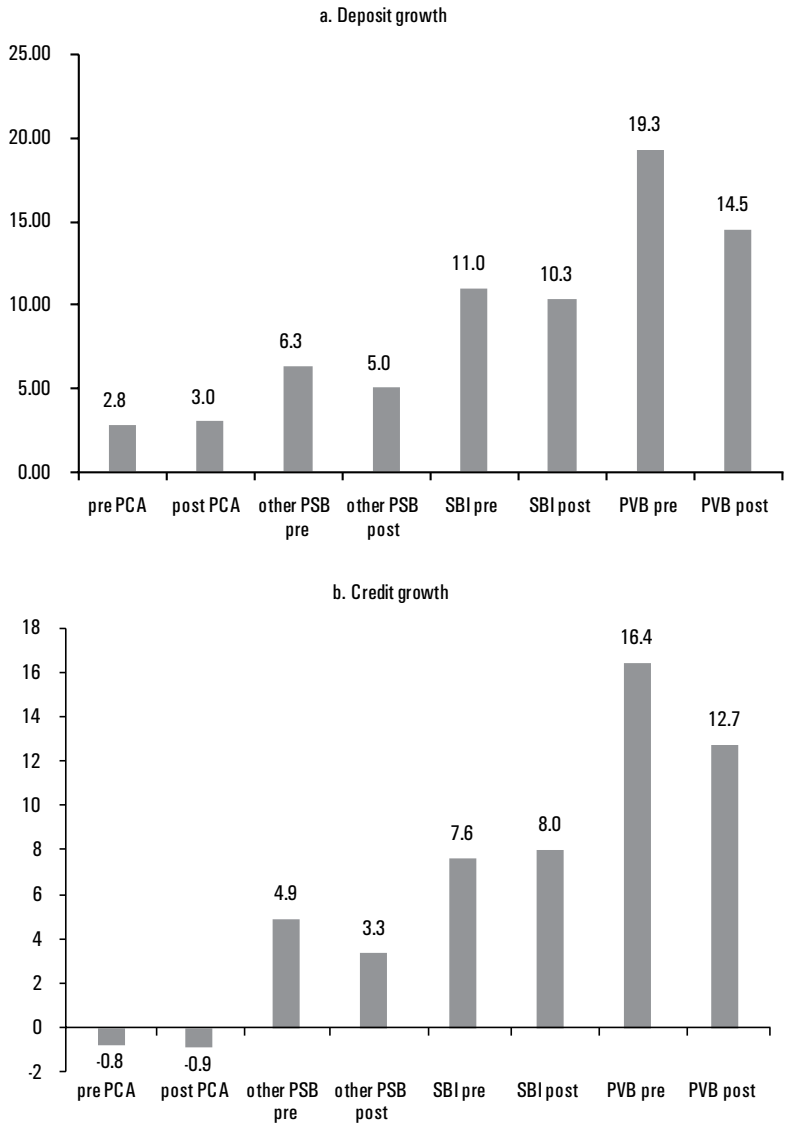
That the answer to the first question is in the negative is readily seen. In April 2017, the RBI had introduced the PCA mechanism to restore the health of banks seen as suffering from low profitability, high NPAs, poor asset quality, and high debt. Under PCA, it imposes restrictions on dividend distribution, branch expansion, salary increases and directors' fees, and new recruitment. It may also choose to conduct special inspections and audits of the bank and a detailed review of its manpower, investments, and processes.

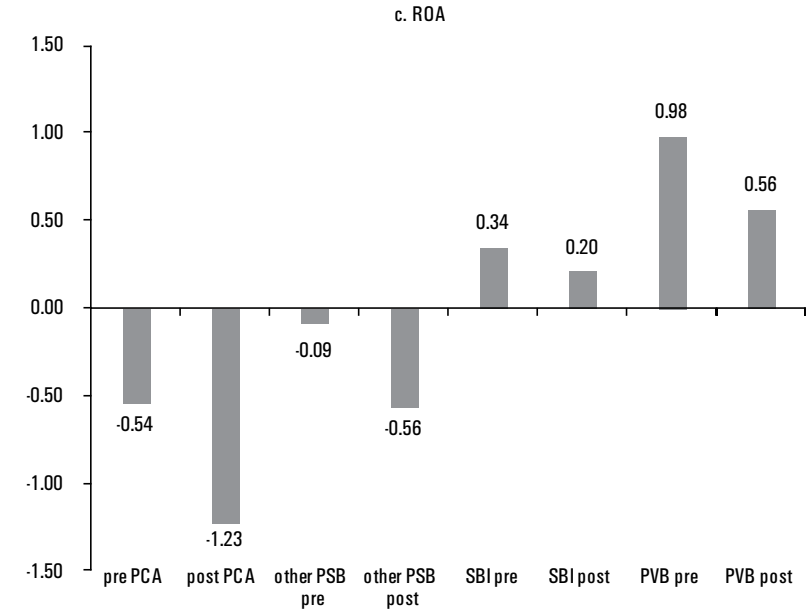
In Figure 18, we present some key indicators of the banks that have been subject to PCA with the view to assess the effectiveness of PCA. For each indicator, we show the values before and after the banks were placed on PCA. Alongside, we also show the values of the same indicator for SBI and private banks as a whole. There is unequivocal evidence that the banks under PCA were performing poorly before they were placed on PCA (which was the reason that they got placed on PCA in the first place), and they showed virtually no

18. Acharya and Rajan (2020) have proposed reforms to bank governance and ownership, especially for PSBs, besides a host of regulatory and market reforms, in order for banking activity to grow significantly in a sustainable manner.

progress after coming out of PCA. Indeed, NPAs actually increased and the return on assets declined. The conclusion that these banks will continue to be a burden on the taxpayer in the years to come is difficult to escape.

FIGURE 18. Performance before and after Prompt Corrective Action

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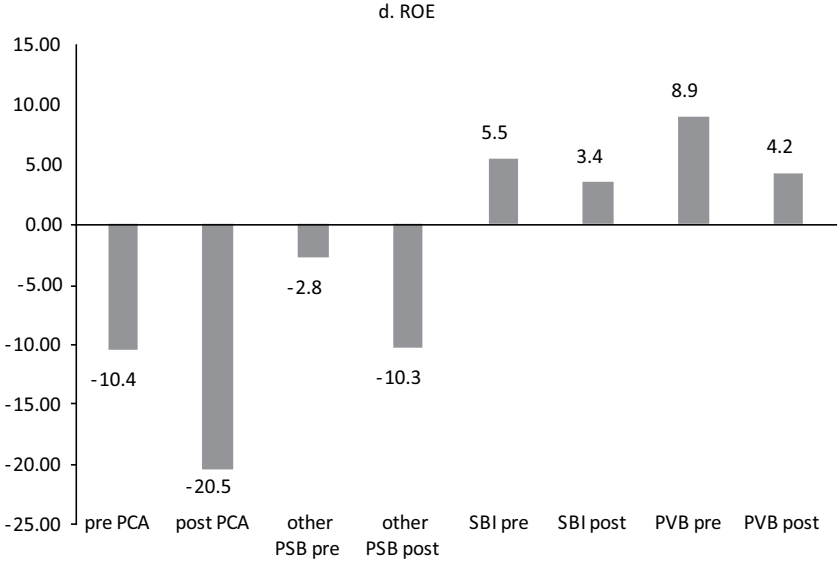
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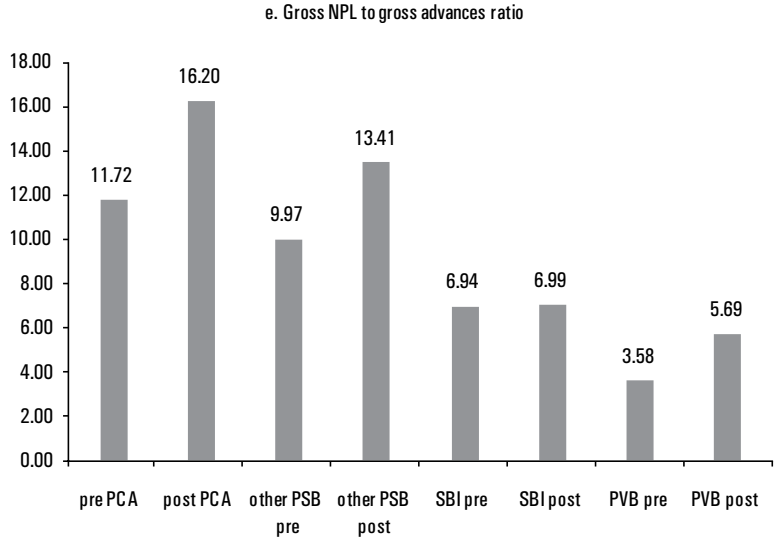

Source: Authors' calculations.
Note: Pre-PCA values include the year of PCA and years prior to it. Post-PCA values include years after PCA and before any mergers of the respective banks.

Turning to question (ii) above, critics of privatization contend that the problems plaguing PSBs can be solved without the transfer of their ownership into private hands. One possible path to it was suggested by the P. J. Nayak Committee in 2014. Under the plan recommended by this Committee, the government would repeal the Bank Nationalization Acts of 1970 and 1980 together with the SBI Act and the SBI (Subsidiary Banks) Act, and incorporate all PSBs under the Companies Act. It would constitute a bank investment company and transfer its holdings in banks into it. After a transition phase of two to three years, all PSBs would come to be governed by professional boards and be subject to the same regulation as private banks by the RBI. The role of the Department of Financial Services would be limited to making policy.

In principle, a plan like this can solve the bulk of the problems plaguing PSBs. Yet, there are two key reasons why we lean against it. First, the process outlined by the Nayak Committee to arrive at the final outcome involves a large number of steps. The Committee, which presumably assumes frictionless implementation, itself estimates the time required to complete these steps to be two to three years. But going by the slow pace at which Indian bureaucracy moves as well as its propensity to place hurdles in the way of even small changes, we remain skeptical that the entire plan would arrive at its final destination even in ten years. The lack of progress in implementing the plan to date reinforces our skepticism. The Committee report has been ready for eight years but PSBs have continued to be run as they were at the time of the appointment of the Committee.

The second problem with taking the route of reform without a change in ownership is that even if a government manages to implement it as per the Nayak Committee plan and schedule, it provides little guarantee that a future government will not reverse it. As long as the government continues to own the banks, the temptation to use them to pursue political objectives will remain. It is wishful thinking that banks can be made to function as genuinely commercial entities without the transfer of ownership in private hands. After all, the aim behind the regulation requiring promoters of private banks to dilute their stake to 15 percent (recently revised to 26 percent) in 15 or fewer years is precisely to minimize their influence over lending and other operations. Why would then governments stop exercising such influence, especially when their time horizon is limited to the next election?

5. Privatization: How and How Far?

In principle, the case for privatization we have made applies to all PSBs including SBI. But we recognize that within the Indian economic framework and political ethos, in the foreseeable future, no government will want to be without a single PSB in its portfolio.[19] Keeping this in view, the goal, whether stated explicitly or left implicit, should be to privatize all PSBs other than SBI, which is by far the largest of the existing PSBs in terms of assets, deposits, and credit, and the best performing one during the critical 2010s decade when the NPA crisis hit PSBs the hardest. It may also be recalled in this context that SBI had been nationalized as early as 1955 on pragmatic grounds and well before the ideological wave of nationalization swept India beginning in 1969. Of course, if some years later, the circumstances turn yet more favorable to privatization, the goalpost may be moved to include SBI in the privatization list.

It may be argued that leaving one bank in the public sector leaves the problem of dual regulation unsolved. Strictly speaking, this is uncontestable. This being said, with all but one PSB privatized, the problem of dual regulation will be considerably alleviated. Even if SBI retains its current share, we can expect a little over 75 percent of bank assets and deposits to move to the private sector once the remaining 11 PSBs and IDBI Bank are moved into private hands.[20] This

19. Patel (2020) in his insightful book, has also discussed the markedly different performances of PSBs and private banks, and the dual regulation of PSBs. He notes "The sovereign and the regulator face a trilemma: It is clear that it is not possible to: (i) have dominance of PSBs in the banking sector; (ii) retain independent regulation; and (iii) adhere to public debt-GDP targets. All three are not feasible on a durable basis; only two out of three can be sustained." Yet Patel does not foresee the possibility of the government letting go of the PSBs out of its control. He notes, "The likelihood that meaningful privatization of banks will be pursued by any government is small."

20. Currently LIC, a public sector enterprise, is the majority shareholder of IDBI Bank. It is expected to pass its stake in the latter into private hands in the near future.

would bring substantial harmony in regulation across banks and help resolve most of the problems arising out of dual regulation. Furthermore, we can expect the government to rule SBI with a much lighter hand than it currently applies to PSBs since without a level playing field, it would risk its only bank rapidly losing market share to private banks. Finally, it is our conjecture that with the bulk of banking moving into the private sector, RBI will also feel the pressure to streamline its processes, rules, and regulations to deliver superior outcomes since the fact of three-fifths of the banking sector being outside its regulatory reach would no longer serve as an explanation for its lapses.

The next question we confront is the pace of privatization. Here our view is that the government should move as rapidly as politically feasible. The reason is that private banks are now clearly outperforming PSBs. It is quite unlikely that this trend will reverse in the coming years. The implication is that privatization of the banking sector as opposed to PSBs themselves is well under way and therefore the latter face a real threat of value destruction over time as has been the case with public carriers in telecom and airline sectors. Going by the past history, there also remains a strong possibility that the longer the government holds on to PSBs that it eventually plans to privatize, the more taxpayer money it would end up sinking into yet more rounds of recapitalization. On the other hand, the sooner the government places PSBs in the private hands, the sooner will they reach their true potential market value and the larger will be the recovery from them.

Even more important, we must not forget the gain to the economy as a whole from rapid privatization. Privatization of PSBs would speed up the privatization of the banking sector as a whole and force the Reserve Bank of India to shape up. With the bulk of the banking sector turning private, the current ambiguity on whether the poor performance of the banking sector is to be attributed to government interference or failure of the regulator would disappear. RBI will have to be fully responsible for proper regulation and smooth running of the banking sector. Therefore, by subjecting banks to genuine commercial pressures and forcing necessary regulatory reforms, rapid privatization of PSBs will contribute to rapid development of a vibrant banking sector. That in turn will contribute to faster economic growth.

The next important question is which banks should be privatized first and how. Taking the "which banks" question first, we may note that in the 2021–22 Budget, the government had announced its intention to privatize two PSBs. Subsequently, multiple media reports have stated that the NITI Aayog has listed four banks as possible candidates for privatization. In order of rising asset value, they are: Bank of Maharashtra, Indian Overseas Bank, Central Bank of India, and Bank of India. These banks respectively accounted for 1.1 percent, 1.5 percent, 2.0 percent, and 4 percent of all banking assets at the end of 2020–21. The media has also reported that a high-level panel of secretaries, headed by the Cabinet Secretary, zeroed in on Central Bank of India (CBI) and

Indian Overseas Bank (IOB) as the top two choices for privatization.[21] The government has neither confirmed nor denied either of these reports.

Given that the reports of these choices remain unconfirmed, we choose not to speculate on their merit or lack thereof. Instead, we proceed to suggest a path that in our view is likely to help sustain privatization till all the 11 PSBs are passed into private hands. It is of utmost importance that the first two banks chosen for privatization should set an example for the success of future privatizations. In other words, markets must see value in the chosen banks and they must be capable of attracting two or more buyers. If no buyers come forward, the outcome will become ammunition in the hands of critics and the government's hand will be dramatically weakened. In contrast, buyer interest and success in transferring the banks into private hands in the very first attempt will establish the credibility of the government. Moreover, immediate increases in the valuations of privatized banks will create buyer interest in other PSBs as they are brought to the market.

In Table 6, we present some key indicators for the twelve PSBs from which (excepting SBI) the first two banks must be drawn. Given the goal of attracting enough buyers and fetching a respectable price in the first go, the three banks that stand out are Indian Bank, Bank of Baroda, and Canara Bank, in that order. These banks exhibit the highest returns on assets and equity, and the lowest NPAs. Their market valuations also exceed the amounts infused to recapitalize them. Among the three banks, Canara Bank, however, exhibits small negative rates of return on assets and equity.

In narrowing down the choice further, an additional criterion may be the current government stake in the banks. The lower the existing government ownership, the easier it may be to privatize any given bank. Applying this criterion, the ranking turns out to be as follows: Bank of Baroda, Canara Bank, and Indian Bank. Alternatively, one may argue that politically the government may find it more attractive to begin the process with a bank with a small asset base. Based on this criterion, Indian Bank would come on top, with Canara Bank and Bank of Baroda tied at second place. Therefore, taking all the five criteria (return on assets, return on equity, NPAs, government stake, and asset base) into consideration, Indian Bank and Bank of Baroda suggest themselves as the two top choices. Between these two, Bank of Baroda would seem to be easier to privatize since in principle, the government will need to divest its stake by only 15 percentage points.

Turning finally to the question of how to privatize, the most critical element has to be full withdrawal of the government from regulation as well as governance and management of the banks. All the powers to regulate the privatized banks must pass on to RBI. A private board with a strict cap on the

21. See https://www.moneylife.in/article/gom-may-consider-privatisation-of-iob-central-bank-this-year/64359.html (accessed on June 9, 2022).

TABLE 6. Selected Indicators for PSBs

Banks	*Percent share in total assets in 2020–21*	*Market cap Rs billion on June 6, 2022*	*Total recapitalization in Rs billion during 2016–17 to 2020–21*	*Net NPA as percent of net advances annual average during 2016–17 to 2020–21*	*Percent return on assets annual average during 2016–17 to 2020–21*	*Percent return on equity annual average during 2016–17 to 2020–21*	*Deposit growth annual average during 2016–17 to 2020–21*	*Share of Government in the Bank as on March 21, 2021*
Punjab and Sind Bank	0.61	103	70.7	6.7	-0.9	-14.9	1.5	97.1
Bank of Maharashtra	1.08	115	90.1	7.2	-0.8	-16.3	4.8	93.3
UCO Bank	1.39	138	217.1	8.2	-1.1	-17.2	3	94.4
Indian Overseas Bank	1.51	332	256.3	9.8	-1.5	-28.5	1.5	95.8
Central Bank of India	2.03	160	213.0	8.5	-0.9	-16.6	4.5	89.8
Indian Bank	3.45	205	183.8	3.7	0.4	5.8	29.4	88.1
Bank of India	4.00	195	297.9	5.6	-0.4	-7.9	4.3	89.1
Union Bank of India	5.90	263	437.4	6.4	-0.4	-7.1	26.7	89.1
Canara Bank	6.35	383	197.6	5.4	-0.1	-1.8	17.9	69.3
Bank of Baroda	6.36	528	227.9	4	0.01	0.1	12.3	64
Punjab National Bank	6.94	347	572.3	7.4	-0.5	-9.3	16.5	76.9
State Bank of India Group	24.97	4145	144.8	3.2	0.2	3.7	10.5	56.9

Source: Reserve Bank of India statistical tables, Groww.com and authors' calculations.

number of government-appointed directors must have the sole responsibility to govern each privatized bank. Within the RBI norms, the power to appoint management and to set the salaries of all bank staff must be vested in the board. Government vigilance agencies must cease to have any jurisdiction over any of the bank employees.

These objectives can be achieved by incorporating the banks under the Companies Act of 2013, placing their operations under an RBI license, bringing government share in equity strictly below 50 percent, and transferring the governance of the bank to a board constituted under the Companies Act of 2013 and the Banking Regulations Act of 1970. The articles of Association of the privatized bank should explicitly limit the number of government-appointed directors on the board to smaller of two and what is permitted under the law by the proportion of equity held by it.

The key to successful privatization is for the government to withdraw from the governance and management of the bank. If potential buyers fear that the government interference will continue, they are unlikely to come forward. This point was painfully brought home during the erstwhile privatization of Air India. The government initially insisted on keeping a 24 percent stake in the carrier, and the result was that it failed to attract a single bid. It was only after it offered to divest 100 percent of its stake that it was able to attract a buyer. In the case of banks, continued partial stake of the government in equity is not a make-or-break issue but any impression that it wants to keep the control of the bank is.

One final prescription for the sales strategy is to give the potential buyer enough flexibility to reconfigure the bank's staff, post privatization. The provisions in the Air India deal regarding staff can serve as a reasonable guide here. Accordingly, employment guarantee should be limited to one year and employee benefits, including those associated with retirement, should be preserved as per industry standards. At the same time, one year after privatization has been concluded, the newly appointed board should have a free hand to re-imagine the workforce as per the bank's skill requirements.

Operationally, the government will first need to amend the legislations nationalizing the banks to allow them to incorporate themselves under the Companies Act of 2013 and to replace their current licenses by those issued by RBI.[22] In the next step, it will dilute its stake to below 50 percent, thereby paving the way for the appointment of a board under the provisions of the Companies Act of 2013, Bank Regulation Act of 1970 and any other relevant laws. The

22. Currently, PSBs are set up as statutory bodies under the relevant nationalizing legislations and operate under licenses derived from them. Incidentally, according to media reports, the government is expected to place before the Parliament a law amending the acts nationalizing the banks other than SBI along the lines mentioned in the text and incidental amendments to the Banking Regulation Act of 1949 in the monsoon session of 2022. See https://economictimes.indiatimes.com/epaper/delhicapital/2022/jun/28/et-front/psb-privatisation-bill-may-allow-govt-complete-exit/articleshow/92502989.cms?from=mdr.

Articles of Association would specifically limit government-appointed directors to smaller of what is justified by its equity and two.

The remaining operational question is how much equity should the government divest and how. Because the success of the privatized bank will principally depend on the new governance structure and the quality of management the board puts in place and not the extent of equity held by the government, the answer to the first of these questions does not depend on any objective criteria. Therefore, the government may choose the level of divestment as per its comfort or revenue needs. For instance, it could retain as much as 49.9 percent of the bank's equity or divest its entire stake.

On the question of how to divest, the first point to note is that all PSBs are currently listed on the stock market. Therefore, a market valuation of each bank already exists and the prospects of allegation that the government undervalued its equity are limited. The fact of listing of the banks on the stock market introduces considerable transparency with respect to the price from the viewpoint of the potential buyers of the shares as well.

Given this fact, there are two broad avenues to disinvestment. First, should the government choose to keep its stake near the 50 percent threshold and its existing stake happens to be less than 70 percent, it would need to divest only 20 percentage points of its shares. To take a concrete example, the current stake of the government in the Bank of Baroda is 64 percent. In addition, Life Insurance Corporation Ltd (LIC), a public-sector enterprise, holds another 5 percent stake in it. Therefore, the government will need to divest 20 percentage-point stake to bring the combined public-sector shareholding below 50 percent. It may do so by publicly committing to selling 4 percentage-point shares on the 15th of each month for five successive months beginning in a specified month. The commitment will have the immediate impact of raising the share price in the market and as the government makes good on its commitment, the price will move towards its expected post-privatization level. The government will thus be able to reap much of the benefit of the higher post privatization price on the shares it chooses to divest.

The second avenue to sale is through a large strategic buyer or a consortium of buyers. Strategic buyers would foresee the post privatization value of the bank from which the government would benefit through a competitive auction involving multiple bidders. The exercise of this option makes more sense in cases in which the government plans to sell a large stake in a bank. One constraint in seeking a single large buyer, however, is that the current banking regulations require the shareholding by a single entity to be brought down to 26 percent or less within 15 years of initial acquisition. This regulation by itself is likely to discourage potential buyers from putting more than 26 percent capital in the first place. This is because investors who create value want to reap the returns on it by holding their investments as long as they are able to generate those high returns. Therefore, if the government takes this route and needs to divest equity worth 30

percentage points or more, it may have to look for a consortium of buyers or sell a part of the shares in the market to retail investors beforehand.[23]

We address two final questions before concluding this section. First, is there a need to reduce the number of PSBs further through mergers before launching the process of privatization? Our answer to this question is in the negative. Based on whatever small data points for recently merged banks exist, we see little scope for value creation through additional mergers. Moreover, the government may find it easier to find buyers for small banks with operations concentrated in specific geographical regions. What the government can do is to allow the buyer of one bank to bid for another in a later auction. This will allow mergers as and when buyers see value in it.

Second, who should be allowed to buy the banks? In our view, the government must cast its net widely, allowing foreign investors including foreign banks, existing domestic banks and non-financial corporate houses to enter the auctions. Banking in India is now at a level of maturity that it can withstand competition from foreign banks.[24] Moreover, these banks would bring innovation in banking. Likewise, letting the existing banks to enter the auctions would open the door to further consolidation in the banking sector. India lacks large banks currently such that even its largest bank, SBI, is smaller than the four largest banks in China.

As regards corporate houses, it is fair to say that the balance of opinion currently is against allowing them to enter banking sector. The commonest argument offered against their entry is that this will lead to crony lending and place depositor interests at risk. Our view is that while this may be a valid argument in abstract, under current Indian conditions, the cost of exclusion of non-financial corporations is significantly higher than that of their inclusion.

Given the scarcity of potential large-scale investors in banks, our options are limited to allowing non-financial corporations to buy PSBs and maintaining status quo of letting PSBs remain in government hands indefinitely. Therefore, the relevant question is not whether there will be crony lending in the banks held by non-financial corporations but whether the overall corny lending will rise or fall when PSBs pass on from government hands to the latter. Our judgment is

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23. In many PSBs, the government holds a stake of more than 80 percent. In these cases, it will indeed need to divest 30 percentage points of equity or more to cross the 50 percent threshold.

24. In a special issue of the *Journal of Banking and Finance* (2005), the editors Clarke, Cull and Shirley summarized the key lessons from a host of papers on the issue of bank privatization in developing economies. The main conclusion that they arrived at is "that although bank privatization usually improves bank efficiency, gains are greater when the government fully relinquishes control, when banks are privatized to strategic investors, when foreign banks are allowed to participate in the privatization process and when the government does not restrict competition." The role of foreign banks since then has been contested for propagating the impact of the global financial crisis. The regulator can contain perceived risks through appropriate measures including by ringfencing the Indian banking operation of a foreign firm, ensuring adequate diversification of ownership amongst the foreign and domestic owners, and through appropriate regulation and supervision.

that with appropriate regulation in place crony lending will fall and, in addition, efficiency will greatly improve if PSBs came out of government hands. For instance, regulation can prohibit the banks held by non-financial corporations from lending to their affiliates and subject any violations to large penalties.

This view is at least partially supported by the fact that we already have some corporations that own deposit-taking non-bank finance companies (NBFCs). We have found no visible cases of wrongdoing in terms of lending to corporate affiliates or otherwise putting the interests of depositors at risk by these NBFCs. On the other hand, it was IL&FS with the Life Insurance Corporation Ltd, a public sector enterprise, as its largest single shareholder and no ownership of non-financial corporations that brought the entire NBFC sector to the doorstep of a collapse in 2018.

A final argument against blocking non-financial corporations from participating in PSB auctions is that today the intersection of information technology and financial intermediation defines the frontier of banking. Telecommunications corporations such as Airtel and Jio have already been granted limited banking licenses. With the interface between technology and banking only likely to get larger, it is myopic to exclude non-financial corporations from banking. A more prudent course is to use their instrumentality to privatize PSBs, develop necessary regulation to minimize the risk and grow the banking sector.

6. Summary and Conclusions

Banks play a critical role in economic growth and in enhancing the well-being of all economic agents, be they households or firms. In India, the banking sector has been dominated by PSBs for nearly half a century due to deliberate policy choices. This has also been a period during which the banks have generally underserved the economy and their stakeholders.

The under-performance of PSBs has been documented and analyzed for nearly two decades. Yet the issue did not gain urgency until recently both because the private banks were considered to be too few in number and too small in size to be able to displace the PSBs; and because the PSBs performed at par with the private banks during a brief period prior to the global financial crisis, casting some doubts on whether ownership was an important determinant of their performance.

In recent years, private sector banks have emerged as a credible alternative to PSBs, having gained substantial market share.

Barring the largest one of them, that is, SBI, most other PSBs have lagged behind private banks in all the major indicators of performance during the last decade. They have incurred larger NPAs and higher operational costs, and have attained lower returns on assets and equity than their private-sector counterparts.

They have lost ground to the private banks in terms of both the deposits attracted and credit advanced. Since 2014–15, almost the entire growth of the banking sector is attributable to the private banks and the largest PSB, SBI.

The under-performance of PSBs has persisted despite a number of policy initiatives aimed at bolstering their performance during this period, such as recapitalization; constitution of the Bank Board Bureau to streamline and professionalize their hiring and governance practices; prompt corrective action plans; and consolidation through mergers, which helped reduce their number from 27 in 2016–17 to 12 currently.

The government infused $65.67 billion into PSBs between 2010–11 and 2020–21 to help them tide over the NPA crisis. Even after this massive infusion of funds, their NPAs remain elevated relative to private banks. Strikingly, the market valuation of PSBs other than that of SBI (as on 31 May 2022) remains hugely below the recapitalization resources infused into them. Meanwhile, private banks have sped ahead by miles in terms of market valuation. The steady erosion in the relative market value of PSBs is indicative of a lack of trust among private investors in the ability of PSBs to meaningfully improve their performance.

In this paper, we have made the case for privatization of PSBs. Our case rests on the following grounds. The first is the superior performance of private banks relative to PSBs. Second, the presence of PSBs potentially destabilizes private banks. This was evident during the global financial crisis of 2008–09 when depositors turned to the implicit safety of the largest PSBs, particularly SBI. Third, government ownership of banks gives rise to many governance issues bearing on both the efficiency of bank operations and the ability of RBI to regulate the sector. Fourth, government ownership brings with it political interference through the flow of loans to serve political objectives. Fifth, regular bailouts of PSBs cost the taxpayer vast sums of money. Finally, government ownership of a subset of banks gives rise to regulatory arbitrariness and ambiguities for all the three stakeholders concerned. The PSBs end up with two masters: the RBI and the government. The RBI ends up with two sets of regulations: one set that applies to private banks and another set to PSBs. The government ends up with the complex and possibly conflicting roles of the owner, regulator, and policymaker in banking.

We propose that the case for privatization applies to all PSBs, including SBI. But we recognize that within the Indian economic framework and political ethos, the government would want to retain at least one PSB in its portfolio. Thus, keeping in view its size and relatively better performance, we propose that the goal should be to privatize all PSBs except SBI for now.[25]

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25. In a book-length account of the crisis-like situation in the banking sector during the last decade, Tamal Bandyopadhyay (2020) reports interviewing past four RBI governors. According to him, most of them would like the government ownership to be pared down significantly. Also see Acharya and Rajan (2020) in this context.

In our view, in the pathway toward privatization of all of the 11 PSBs, it is important that the first two banks chosen for privatization set an example for the success of future privatizations. The banks chosen may be the ones with the highest returns on assets and equity, and the lowest NPAs in the last five years. To this, additional criteria may be applied such as the current government stake in the bank and its size. The lower the existing government ownership, the easier it may be to privatize any given bank. Likewise, politically the government may find it more attractive to begin the process of privatization with a bank that has a small asset base.

As regards the question of how to privatize, the most critical element has to be the withdrawal of the government from regulation as well as governance and management of the banks. All powers to regulate the privatized banks must pass on to the RBI. A private board with a strict cap on the number of government-appointed directors must have the sole responsibility to govern each privatized bank. Within the RBI norms, the power to appoint management and to set the salaries of all bank staff must be vested in the board. Government vigilance agencies must cease to have any jurisdiction over any of the bank employees.

The first step for privatization to take place would be to incorporate the banks under the Companies Act of 2013, placing their operations under an RBI license, bringing government share in equity strictly below 50 percent, and transferring the governance of the bank to a board constituted under the Companies Act of 2013 and the Banking Regulations Act of 1970. The number of government-appointed directors on the board to smaller of two and what is permitted under the law by the proportion of equity held by it.

With the proposed governance structure, the government may choose the level of divestment as per its comfort or revenue needs. For instance, it could retain as much as 49.9 percent of the bank's equity or divest its entire stake.

There are two broad avenues to disinvestment. First, should the government choose to keep its stake near the 50 percent threshold and its existing stake happens to be less than 70 percent, it would need to divest only 20 percentage points of its shares. It may do so by publicly committing to selling 4 percentage-point shares on the 15th of each month for the required number of months beginning in a specified month. The commitment will have the immediate impact of raising the share price in the market and as the government makes good on its commitment, the price will move towards its expected post-privatization level. The government will thus be able to reap much of the benefit of the higher post privatization price on the shares it chooses to divest.

The second avenue to sale is through a large strategic buyer or a consortium of buyers. Strategic buyers would foresee the post privatization value of the bank from which the government would benefit through a competitive auction involving multiple bidders. The exercise of this option makes more sense in cases in which the government plans to sell a large stake in a bank.

We have addressed two final questions in the paper. The first is whether there should be further consolidation of the sector through mergers before the process of privatization is launched. We see little scope for value creation through additional mergers. If anything, the government may find it easier to find buyers for small banks with their operations concentrated in specific geographical regions.

The second question is: Who should be allowed to buy the banks? In our view, the government must cast its net widely, allowing foreign investors including foreign banks and domestic investors, including domestic banks and corporate houses to enter the auctions with due diligence. Any potential risks associated with corporate ownership or foreign banks may be minimized by letting a consortium of corporations enter the bidding with the stake of any single corporation capped; ringfencing the Indian banking operations of a foreign firm; and through appropriate regulation and supervision.

While we have provided a preliminary roadmap for privatization in the sector, the timing and manner in which it is undertaken will ultimately be a political call. In cognizance of the fact that there may be very little or no privatization at all during the next one decade, we project the implications of this scenario too. On the basis of the relative pace of deposit collection and credit advancement since 2014–15, we project that in a business-as-usual scenario, PSBs other than SBI will shrink further and become faded entities, accounting for only 4.4 percent of the deposits, 9.4 percent of credit, and 8.4 percent of the assets in 2032–33. SBI has had a surprisingly steady market share of about 22–25 percent and will continue to operate at that level. All the rest of the banking operations will reside with the private banks.

Meanwhile, if the status quo is maintained, it will lead to the following results: (i) the various constituencies of the PSBs will continue to be underserved; including the depositors of the banks, who would be deprived of higher interest rates, better customer services, and the benefits of digital banking; (ii) the productive firms, who will find it hard to get credit at market rates; (iii) the RBI who will struggle with dual regulation and an impeded monetary policy transmission through the PSBs; and (iv) the government, who will be saddled with poor valuations and demand on its limited fiscal resources.

Eventually, these costs will have macro-economic implications of lower economic growth; slow progress in financialization of savings, and diversion of scarce resources from more worthy social goals.

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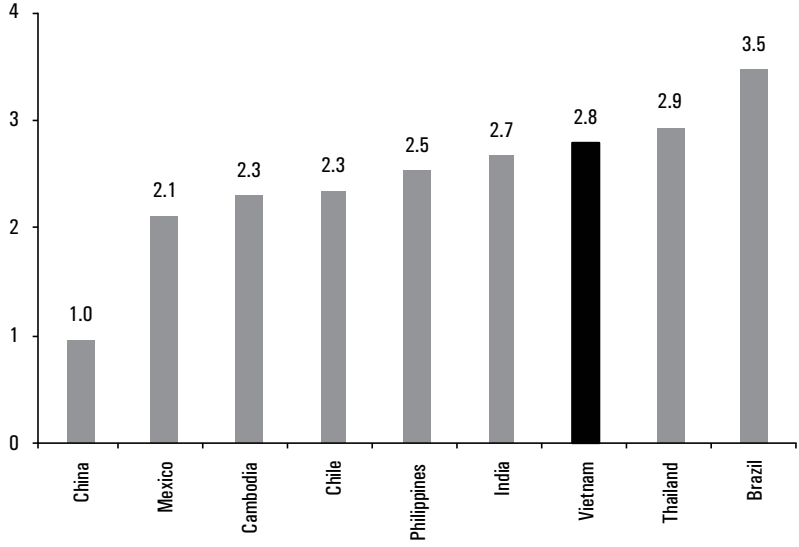
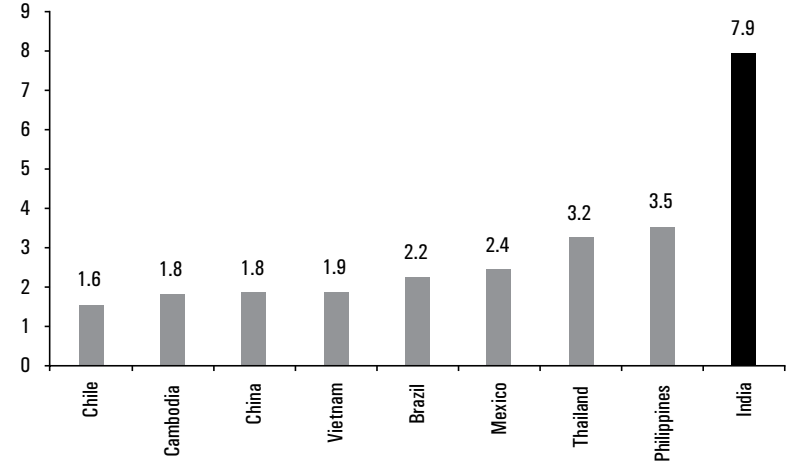
Appendix

FIGURE A1. India's NPA Ratio Remains Higher than that of Most Other Comparator Countries

a. Bank Non-performing Loans to Total Gross Loans (%) in 2011

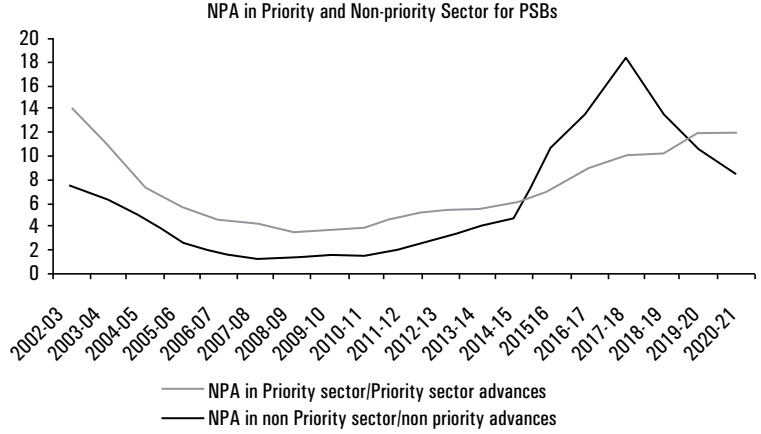


b. Bank Non-performing Loans to Total Gross Loans (%) in 2020



Source: World Development Indicators (World Bank).

FIGURE A2. NPAs Incurred by PSBs in Priority Sectors versus Other Sectors



Source: RBI, statistical tables relating to banks in India (Composition of NPA's of Public Sector Banks, data availability from fiscal year 2003 till 2021).

Note: Non-priority sector NPA calculated as Total NPA minus NPA in Priority sector. Similarly, Non-priority sector advances calculated as Total Advances – Priority sector advances. Systematic data for private banks separating NPAs in priority sector are not available.

To view the entire video of this IPF session and the General Discussion that ended the session, please scan this QR code or use the following URL
https://youtu.be/aU7ZkP2H5P0

Comments and Discussion*

Chair: **Manish Sabharwal**
TeamLease and NCAER

Ashwini Tewari

State Bank of India

Banks in India transited from a controlled environment to a substantial operational autonomy post 1991 when interest rates were liberalized. The private banks then (called old private banks now) were mostly community-based, family-owned small banks. The real success of the private sector banks, as is understood now, is largely due to the 4–5 professionally run banks, some of which were set up in 1994–95 and some later. The community owned, old private banks have remained small and have not been very successful. The latest entrant to private banks, Bandhan bank is still finding its feet but it has a very different business model with a focus on low cost deposits and small value loans from a large number of customers.

As far as Public Sector Banks (PSBs) go, their relatively unsatisfactory performance since 2010 has reasons. From financial year 2005–06 onwards, PSBs funded large infrastructure projects whereas private sector banks largely stayed away and focussed on retail lending. These infrastructure projects did not work for reasons that are well known like delays in clearances, land acquisition, overtly positive assumptions etc. Interestingly majority of these projects were privately owned. They become stressed and the restructuring schemes did not work. With the Asset Quality Review by RBI in 2016–17, they become NPAs. Since these were very large loans cutting across PSBs, the resolutions though aided by the Bankruptcy Act, took a long time and government had to infuse a lot of capital into the PSBs. The large NPAs led to bank balance sheets getting stressed making fresh lending difficult even as the corporate balance sheets were also leveraged leading to what is called twin balance sheet problem. This has now been largely cleaned up.

Private banks continued to lend to retail leading to better numbers shown by them in this period. In the last 5–10 years though, PSBs have also focused on retail lending and have nearly caught up with PVBs. As far as lending to MSME sector is concerned, there is an estimated requirement of INR 20 trillion

* To preserve the sense of the discussions at the India Policy Forum, these discussants' comments reflect the views expressed at the IPF and do not necessarily take into account revisions to the conference version of the paper in response to these and other comments in preparing the final, revised version published in this volume. The original conference version of the paper is available on NCAER's website at the links provided at the end of this section.

which is partly funded by banks and for remaining, MSMEs resort to high cost, unorganized lending. We however see that the MSME has mostly small subscale units which are not able to sustain market recessions. They are also mostly suppliers/vendors to large units and hence require a whole ecosystem support, banking being one element. Agriculture is also evolving with high tech firms coming in. PSBs have realised that opening branches everywhere is not viable and hence are using Business Correspondent (BC) model and also co-lending with NBFCs. It is explained in the paper that private banks have created more employment and opened more branches than public sector banks. We have to examine, however, that this may be because of the higher number of PSB employees and branches to begin with, which now needs some rationalization. Even today PSBs have higher number of employees and branches compared to their market share. Private Banks have now realised that they do need bigger branch network to get more business. The entry of FinTech and BigTech in the ecosystem for financial inclusion is also a new factor.

Regarding privatization of PSBs, if we hypothetically assume all PSBs are privatized, where would we have a bank to handle crises, like SBI helping a leading private bank in 2020. Further we have seen the active role played by PSBs in financial inclusion – opening of Jan Dhan Accounts, Micro insurance (PMJJBY/PMSBY), micro pension (Atal Pension Yojana) all of which have seen a very limited private Bank participation much below their market share.

India is a developing country needing State support which needs banking vehicles such as PSBs. Whether private banks can play this role is not borne out by their reluctance to participate, so far.

SBI has the experience of successfully creating world-class companies in asset management, insurance, credit cards, among others, where SBI owns majority, seconds the CEO to these companies, and others are hired from the market. This approach has proved successful due to independence given to the boards and the professional approach of the bank.

Thus, greater autonomy is perhaps the way to go and I would argue why privatize, why not create more SBIs.

Ruchir Agarwal
International Monetary Fund

Summary of the 'Privatization of Public Sector Banks in India'

The paper by Gupta and Panagariya (2023) puts forth a compelling argument for privatizing India's PSBs. They broadly make four points:

- *Why privatize?* The paper argues that the current situation is bad for economic growth due to the unending cycle of non-performing assets and

recapitalization, which puts a fiscal burden on the government.

- *Which banks?* Their proposed solution is to sell off all public banks except for the State Bank of India, which would harmonize regulation and limit growth and fiscal costs while satisfying social objectives.
- *How to privatize?* The authors argue for rapid privatization to preserve value and limit costs. They want to prioritize the most viable and small public banks with a lower government stake. They recommend that government must also withdraw from governance and management of public banks to ensure successful privatization.
- *Who can buy?* Given the scarcity of potential buyers, the authors suggest expanding the pool of potential buyers, which should include corporates—while limiting related-party lending.

Altogether, the authors argue that rapid privatization is a viable solution to address the issues faced by public banks in India and improve economic growth.

The Case for Privatization: My Assessment

Overall, I agree with the authors that privatizing public banks will positively impact India's economy and remains a key priority. However, I want to emphasize a few nuances that we must consider when designing India's bank privatization strategy.

First, I would caution against focusing on the recent performance of public banks relative to private banks. During the 2010s, many public banks were placed under *prompt corrective action* (PCA) by the Reserve Bank of India (RBI), which prevented them from operating freely. Several public banks were not allowed to open new branches or grow their loan books until they reduced their sizable non-performing assets. Thus, comparing constrained banks (which represented a large share of the public banks) with unconstrained banks (nearly all private banks) is not an apples-to-apples comparison. Nevertheless, the case for privatization is strong even without making such comparisons—especially considering (a) the large fiscal costs of recapitalization and (b) the distortions in capital allocation. Thus, I would encourage the authors and future work in this area to focus on those two alternate arguments for privatization—while fully accounting for the history of RBI's supervisory actions. See Acharya (2018) and Agarwal (2023) for a detailed discussion of these issues.

Second, we must consider the social objectives that public banks have served, such as providing banking services to remote and underbanked areas. It is essential to place the privatization strategy in the broader context of India's development goals. In this context, it would be helpful to assess the geographic and sectoral reach of the public banks, and identity the suite of complementary

policies needed alongside privatization. Future work could pay more attention to identifying and sequencing such complementary policies.

Third, and most importantly, I would encourage us to situate the debate on privatization within the broader context of financial sector reform and growth drivers in India. From my perspective, this requires addressing three macro-financial challenges: (1) India's Great Funding Imbalance; (2) India's Financial Deepening Hurdle; and (3) India's Macro-Finance Trilemma. The rest of this note focuses on these three challenges in the context of the broader financial sector reform.

Challenge #1: India's Great Funding Imbalance

Banks in India mostly follow a conventional model. They collect money from people who deposit money and borrow money from the market. Then they lend this money to other people, companies, or institutions or use it to invest in government securities. Recently, Indian banks have been lending more to non-bank financial institutions—namely the Non-bank Financial Corporations (NBFCs) and Housing Finance Corporations (HFCs).

However, in India, public and private banks have different ways of collecting money.

First, private banks depend on market borrowing more than public banks. In 2019, before the pandemic, private banks borrowed 17 percent of their interest-bearing liabilities from the market, compared to 8 percent for public banks. Second, private banks don't get as much money from regular depositors as public banks. In 2019, only 33 percent of private banks' interest-bearing liabilities came from retail deposits, compared to 60 percent for public banks.

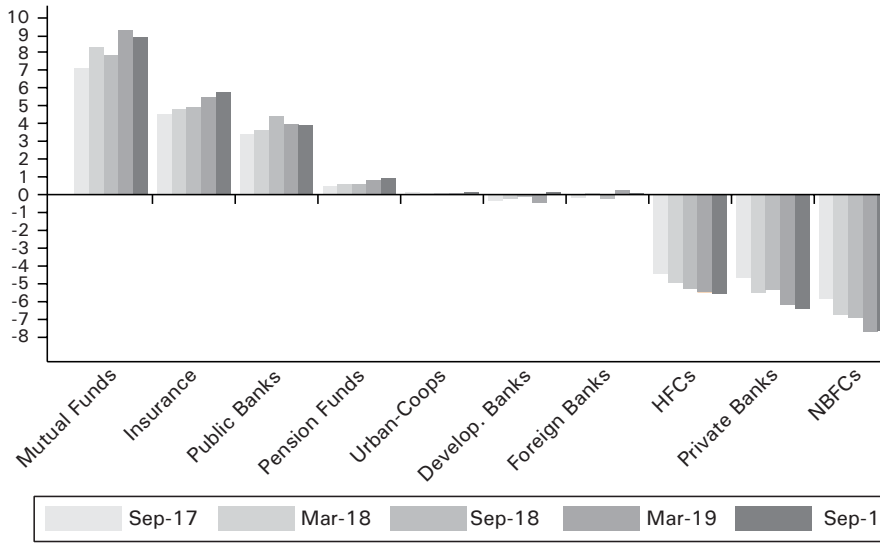
Because of these differences, only one-third of private banks' funding is "sticky" (i.e., based on retail deposits). Thus, private banks must compete to borrow money from the market, money markets, and large institutional depositors. This means that private banks are more vulnerable to funding risks. If the market stops lending money or if there are concerns about the bank's health, it can be difficult for private banks to get the money they need. This funding risk is especially relevant for banks that lend a lot, and for newer or weaker banks that struggle to get individual depositors.

However, in the 2010s, after 11 public banks and one private bank were placed under PCA by the RBI, there was a new reality in the banking sector. Many public banks faced lending constraints (due to the PCA) but had easy access to depositor funding; meanwhile, private banks sought to lend more aggressively but didn't have easy access to depositor funding. Thus, between 2013 and 2018, private banks aggressively sought to grow their depositor base (which grew 10–15%), while public banks were compelled to shed deposits (with deposit growth going to zero).

Then, the default of two major non-bank financial institutions (IL&FS and DHFL) in 2018 and 2019 led to significant disruptions in the wholesale and money markets. In the aftermath, many private banks faced increased competition for deposits, while several non-bank financial institutions struggled to maintain a stable funding base. Consequently, dispersion rose in the credit-deposit ratios of banks in the system—with a significant increase in the ratio for private banks and a decline in the ratio for public banks. At the same time, the interbank market in India shrank. Further, after the 2020 collapse of Yes Bank, a fast-growing private bank, depositors became more averse to trusting private banks.

We can see the greater reliance of private banks on market borrowing by examining the cross-linkages in the Indian financial system (Figure 1). In inter-sectoral exposure, mutual funds and insurance companies were the major fund providers to the system, while NBFCs and HFCs were the major receivers of funds. However, experience varied within the banking system: private banks were net receivers relative to the entire financial sector, and public banks were net providers. As Figure 1 demonstrates, the private banks' dependence on the rest of the financial system is like that of the NBFCs and HFCs — highlighting their high non-deposit funding needs.

FIGURE 1. Net Receivables/Payables by Institutions (Rs Trillions)



Source: Author's calculations.

Note: RBI. Exposures among entities in the same sector are excluded.

This large and persistent dispersion in the funding model of Indian financial institutions is what I call the *Great Funding Imbalance*. The Imbalance arises

due to (a) the public sector banks and a few highly reputed large private banks enjoying access to cheap depositor funding, while (b) the rest of the financial system remains starved for funding despite having unique lending opportunities in the vast Indian economy. In this context, classic asymmetric information issues combined with specific shortcomings in India's wholesale funding market generate a significant financial distortion across the entire financial system. A major consequence of this Imbalance—and the associated financial distortion—is costlier finance for many Indian households and businesses, especially those that live beyond the sunshine of the Tier 1 cities or the big business houses.

India's Great Funding Imbalance was muted during the COVID crisis—mainly due to the RBI's massive injections of aggregate liquidity. In the first 18 months of the pandemic alone (Feb 2020 to Sept. 2021), the RBI implemented liquidity measures worth 8.7 percent of the GDP. Even afterward, the RBI has kept the financial system flush with surplus liquidity, even though the acute phase of the pandemic is over. However, persistently high inflation may put greater pressure on the RBI to withdraw liquidity. Once the wave of aggregate liquidity recedes, the funding imbalance will become prominent again. This is especially concerning as many much-needed reforms in the financial system could not be prioritized due to the pandemic and remain unaddressed.

Any privatization efforts or reorganization of the Indian financial system is an opportunity to address the Great Funding Imbalance. A significant risk is that India's retail deposit base becomes concentrated in the hands of a few large private banks. That scenario will lead to a persistence of the Imbalance, just under a different guise. Based on my study of the system, such an outcome is likely to hinder India's growth significantly (Agarwal 2023). Instead, ensuring better access to stable and cheap funding for medium-sized banks, NBFCs, and HFCs will potentially support convergence in incomes across States, rural and urban areas, and families. This may require some well-managed non-banks to become deposit takers. It will also require careful attention to the ex-post distribution of deposits in the banking system after the privatization of public banks.

To summarize, the concrete implication of challenge #1 is to situate the privatization efforts amidst a broader strategy to address India's Great Funding Imbalance. This could include the following steps:

A. Design a path for well-managed non-bank financial institutions to convert into deposit-taking institutions, which could participate in the privatization process.
B. Consider mergers between strong and well-managed non-bank financial institutions and smaller (public and private) banks.
C. Support the development of the wholesale funding market—including by reducing asymmetric information through frequent and transparent asset quality reviews. This will reduce the funding advantages of public banks,

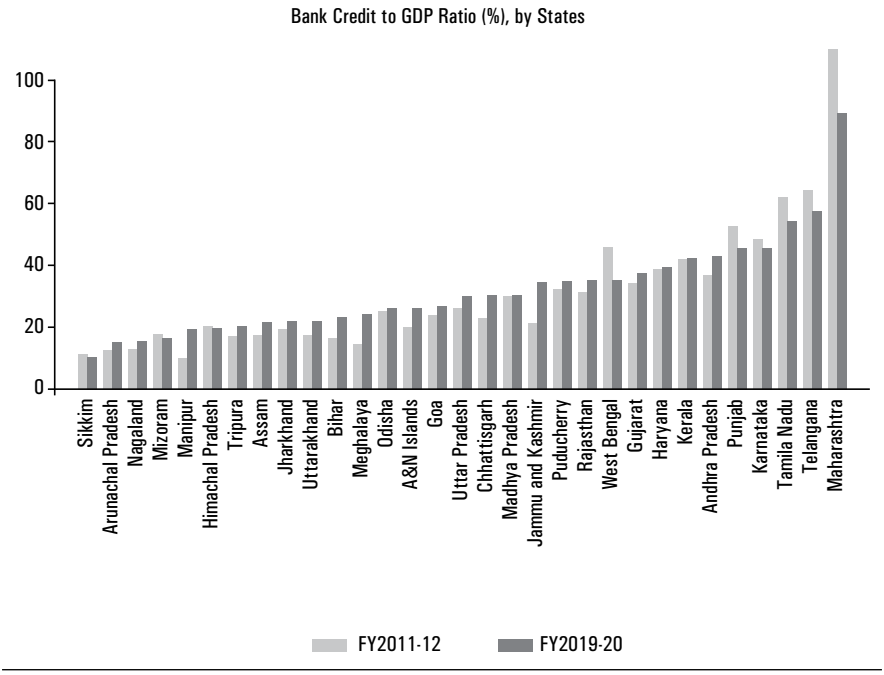
in turn helping address the underlying problems that lead to the need for privatization in the first place.

Challenge #2: India's Financial Deepening Hurdle

The Financial Deepening Hurdle for India is the critical need to increase access to financial services across the country, including credit and insurance. One way to measure this challenge is through the credit-to-GDP ratio, which represents the amount of credit provided by banks relative to the size of the economy.

Credit-to-GDP ratios remain very low in poorer States—and are up to three times lower than those in richer States (see Figure 2). For instance, the credit-to-GDP ratio in Bihar and Uttar Pradesh, two of the country's most populous States, is much lower than the national average. Bihar and Uttar Pradesh (where about 1 in 4 Indians live) have credit-to-GDP ratios between 20-30 percent, compared to the national average of over 50 percent. Many people in these States have limited access to credit, which can impede their ability to start businesses, invest in education or healthcare, and build wealth.

FIGURE 2. Bank Credit to GDP Ratio (%), by States



Source: Author's calculations.

Note: Delhi and Chandigarh are not depicted as both have values above 150%.

The dispersion in the credit-to-GDP ratio can have significant consequences for the overall growth and development of the country. When some regions have limited access to credit, it can lead to a less efficient allocation of resources, hampering economic growth and exacerbating regional disparities.

In recent decades, the government of India has taken steps to address the financial deepening hurdle. For instance, the Pradhan Mantri Jan Dhan Yojana, a national financial inclusion program launched in 2014, aims to provide every household with access to basic financial services. And, as Figure 2 shows, there has been a modest increase in the credit ratios among the poorer States during the 2010s.

Yet, since the 1970s, India's primary financial deepening tool has been Priority Sector Lending (PSL). Under this policy, banks must lend 40 percent of their total credit to agriculture, small-scale industries, and other marginalized sectors.

Banks that fall short of meeting the required percentage of lending to priority sectors can make up for the deficit in one of three ways. They either (i) purchase Priority Sector Lending Certificates (PSLCs) from other banks, or (ii) invest in Rural Infrastructure Development Fund (RIDF) deposits, or (iii) lend funds to non-bank institutions for "on-lending" to priority sectors. Private banks tend to be more active in buying PSLCs and in on-lending to non-banks to meet their priority lending targets—as public banks are more active in priority sectors due to their historical and social role. Thus, the burden of this policy de facto falls much more on the public sector banks than the private banks.

The priority sector lending policy has several shortcomings. For instance, the policy incentivizes banks to lend to specific sectors and areas, regardless of their creditworthiness. Also, the policy leads to a crowding-out effect, as banks divert funds from profitable sectors to meet their priority sector lending targets. This results in reduced profitability and competitiveness of banks, ultimately harming the economy. Lastly, it has increased financial stability risks as it has deepened interlinkages between banks and non-banks due to on-lending activities.

Overall, it will be important to assess how the privatization efforts interact with the distortive effects of priority sector lending and related policies. Further, priority sector lending is a type of "push policy" as it pushes finance first and waits for growth to happen. Instead, there is a need for greater emphasis on "pull policies" that encourage the development of a pipeline of high-quality projects in all areas of the economy. Without attention to such complementary policies, the privatization efforts may not yield the desired benefits and could even heighten the systemic interlinkages in the system.

To summarize, the concrete implication of challenge #2 is to ensure that the large-scale privatization of Indian public banks is part of a comprehensive strategy to overcome India's Financial Deepening Hurdle. This could include the following steps:

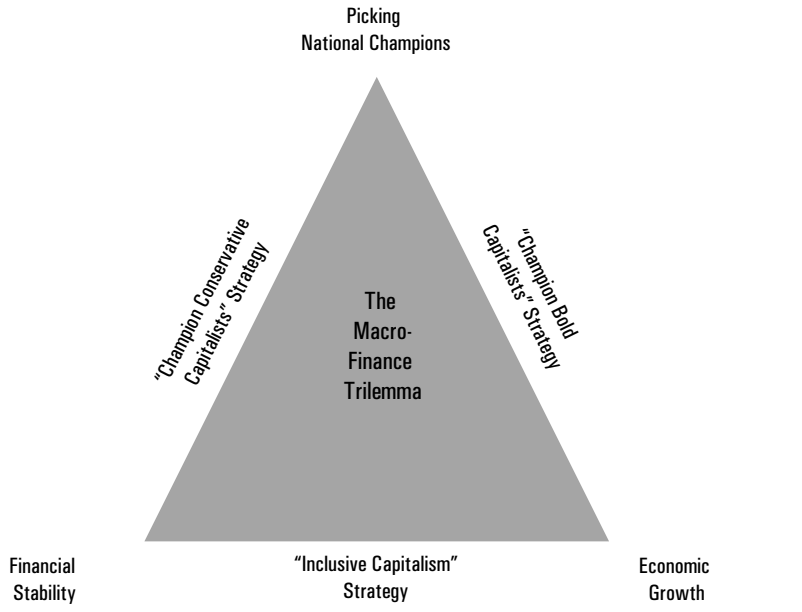
A. Assess the effectiveness and distortions of the priority sector lending and related policies; identify how they interact with the privatization of public banks.
B. Place greater emphasis on "pull policies" to develop a strong pipeline of projects in neglected areas (e.g., through enhancing the credit registry system for small and medium enterprises and first-time borrowers).
C. When choosing a pool of buyers, pay attention to the lending functions of public banks and their niches (e.g., geographies, sectors, etc.).

Challenge #3: India's Macro-Finance Trilemma and Growth Anxiety

The macro-finance trilemma presents a complex and nuanced challenge for governments seeking to promote economic growth, financial stability, and national champions. Pursuing any two of these objectives necessarily comes at the cost of sacrificing the third, making it a trilemma. I call this the Macro-Finance Trilemma (see Figure 3).

When a government champions conservative capitalists, it aims to prioritize financial stability and the selection of safe national champions while sacrificing high economic growth. Such a strategy often prioritizes prudence and caution over the potential benefits of a more aggressive growth strategy.

FIGURE 3. The Macro-Finance Trilemma



Source: Author's representation.

In contrast, championing bold capitalists focuses on prioritizing economic growth and the selection of aggressive, market-oriented national champions. However, this comes at the cost of financial stability, as higher risks and poor governance may undermine the overall stability of the financial system.

Finally, the inclusive capitalism approach prioritizes financial stability and economic growth—without picking national champions (and instead promoting free entry). This strategy may seem the most favorable of the three, but governments may avoid it due to growth anxiety. This is because governments may have limited control over the growth outcomes when pursuing this approach due to a higher variance in growth outcomes. This option may also become unfavorable at certain times, for instance, due to electoral cycles and the political urgency of delivering sufficient growth for the masses.

Overall, the macro-finance trilemma presents a challenge to governments—as they must carefully balance the competing demands of financial stability, economic growth, and selecting national champions. Ultimately, the best approach will depend on a range of contextual factors, including the state of the economy, the financial system's health, the government's policy priorities, and electoral pressures in the political system.

How does the trilemma apply to India? In the Indian context, the historical dominance of business houses such as the Tata Group or Bajaj Group could be an example of the "Championing Conservative Capitalists" growth strategy. Such prominent business houses are known for their conservative approach to business, focusing on long-term sustainability. They often operate across multiple sectors as their reputation for integrity has helped them build trust with customers, employees, and investors, which has helped them weather economic and political storms over the years. Due to their long-standing dominance and influence in certain sectors, such as steel and automobile production, such business houses have established themselves as national champions. Their champion status is further strengthened through the implicit support they receive from the government, including regulatory advantages and other supportive policies.

On the other hand, the Infrastructure Leasing & Financial Services (IL&FS) crisis in 2018 could serve as an example of the "Championing Bold Capitalists" strategy. IL&FS was a shadow banking company that relied on short-term borrowing to fund long-term infrastructure projects. When its debts became unmanageable, it defaulted on its obligations, causing a panic in the market. This failure exposed the risks of shadow banking and highlighted the importance of financial stability.

Where does bank privatization fit in this trilemma? The potential privatization of India's public sector banks, with an implicit preference for large, well-established private banks, could exacerbate the country's macro-finance trilemma. By favoring existing winners, the government risks perpetuating a model of "quiet banking" among profitable banks (Bertrand and Mullainathan,

2003)—that lack incentives to lend to underbanked regions or non-traditional areas such as rural India or Tier 2 and 3 cities. This, in turn, could exacerbate the country's financial deepening challenges and increase the concentration of the banking system, leading to anti-competitive outcomes and potentially creating "too-big-to-fail" institutions that pose contingent fiscal liabilities.

Furthermore, picking winners in the privatization process could lead to a winner-takes-all dynamic, further entrenching the dominance of established players in the financial system. This could limit the entry of new players and stifle competition, thereby impeding innovation and growth. Additionally, concentrating power in a small number of large banks could deepen the macro-fiscal nexus, as these banks become more intertwined with the government and pose a greater risk to fiscal stability in the event of a crisis.

Considering these risks, policymakers should carefully consider the implications of any privatization efforts and avoid perpetuating a system that favors incumbents at the expense of financial inclusion, competition, and stability. A more balanced approach, which incentivizes all banks to lend to underserved areas and fosters competition through measures such as easing entry barriers, could help address these challenges and promote a more inclusive and resilient financial system.

To summarize, the concrete implication of challenge #3 is to pay careful attention to India's Macro-Finance Trilemma when scaling up privatization efforts for its public banks. This could include the following steps:

A. Resist picking champions, promote free entry, and harmonize regulations.
B. Consider the ex-post market concentration in deposits and 'too big to fail' considerations when selecting the pool of buyers for privatization.
C. Avoid applying 'survival-of-the-fittest' notions to the financial system—in which the regulators implicitly favor large profitable banks—since there can be significant macroeconomic spillovers from the closure of certain banks and financial institutions (due to the specificity in lender-borrower relationships).

Summary

Overall, privatizing public banks is a positive step for India's economy, and I commend Gupta and Panagariya (2023) for presenting a compelling case. At the same time, we must consider a few nuances when devising the privatization strategy.

First, comparing public banks under prompt corrective action to unconstrained private banks may paint an inaccurate picture. However, the case

for privatization still holds up due to the high fiscal costs of recapitalization and due to capital allocation distortions.

Second, we should consider the social objectives of public banks in providing banking services to underbanked areas. Privatization must be achieved without sacrificing the broader development goals of India.

Lastly, the privatization debate must be situated within the context of broader financial sector reform and address three macro-financial challenges: (1) India's Great Funding Imbalance; (2) India's Financial Deepening Hurdle; and (3) India's Macro-Finance Trilemma. All three challenges have one significant implication: The pace of privatization and sequencing of complementary reforms should carefully consider these concerns.

One final point in the privatization debate is the unaddressed governance issue in private banks. Major failures like Global Trust Bank (2004), Yes Bank (2020), and the recent criminal investigation against the chief of ICICI Bank show that privatization does not guarantee efficient resource allocation. In such cases of bank failure, public banks had to bail them out, leading to indirect fiscal costs. Thus, governance reforms remain an essential prerequisite for the successful privatization of public banks.

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General Discussion

Prachi Mishra opened the discussion on the paper by raising a few questions on data and policy. Endorsing the comments of the discussant Ruchir Agarwal, she said that it would be prudent to provide a more wholesome picture of external and non-bank sources of finance in the paper. She said that a clear distinction needs to be made between banks that had been nationalized in 1969 and 1980, and some others like Lakshmi Village Bank and South Indian Bank Mercantile Bank, which were deemed to be too small and looked exactly like

State-owned banks, were different from the State Bank of India and other State-owned banks. Since the issue of credit is heterogeneous, it would be desirable to see how it varies by the type of banks or private or public sector banks or others. Regarding the questions on policy, first, more details are required on the progress of the privatization of banks that has already been announced. Second, is there a case for going slower in terms of allowing strategic investors and more well-regulated listed financial institutions 5–20 percent minority stakeholding, which should be large enough to ensure that there is some incentive for actual governance and engagement and market discipline without full-blown privatization? Third is the alternative approach to allow more bank licences, as given the size of the country, the banking sector is pretty concentrated and the share of public sector banks has declined over time. So, why not allow a more organic way of reducing their share in the market rather than thinking about full-blown privatization, which is politically difficult?

Ram Singh posed two questions to the authors. He said that though SBI and other public sector banks are subject to the same regulatory governance structure, yet the performances of the latter are very different from that of SBI. In contrast, the performance of SBI is comparable to the best of private sector banks, and it is important to identify the reasons for this skew in performance. Does it have something to do with the size of the bank, that is, does size matter more for a public sector bank as compared to private sector banks? Another pertinent question with regard to public sector banks is that they have had a disproportionate exposure to the infrastructure sector but they are also victims of big-size defaults and "scams". So, if these are treated as one-off incidents, do the banks still come across as inferior in terms of performance standards as compared to private sector banks?

Rohini Somanathan praised the paper for being highly informative. In the context of her extensive work on self-help groups (SHGs) in Jharkhand and northern Odisha, she flagged an RBI circular issued in 1991, which really started off the SHG movement in India, and completely transformed the rural landscape in many of these areas. Basically, that circular said that if a group of women wishing to start some venture wanted to open accounts but did not have any identity proofs, how could one open accounts for them? There was very little oversight and little regulation in the poor parts of Jharkhand. The SHG meetings in the villages were transformative and enthused the women, and completely changed lives. But the deposits were tiny, as each of the women was contributing just five rupees a week at that time, and consequently, the cost of maintaining the accounts was pretty high. Since the default rates were very low as compared to the other priority sector lending such as agriculture at the time, would this experiment be perceived as a success from the financial perspective? She also asked if the authors had thought about the issue of spatial distribution because when these banks developed, there was a lead bank scheme. A lot of

the rural lending, especially in the States, was therefore, done by one particular bank. Hence, what implications would bank privatization have for rural lending in that particular State and what could replace that lending?

Dilip Mookherjee contrasted the superior operational efficiency of the private banks with the social objectives that may be better served by the public sector banks. He also flagged the heterogeneity within both the public sector banks as well as the private sector banks. This gives rise to the possibility of an intermediate option, which is to consolidate the public sector banking assets into the SBI, which seems to be more efficient than the other public sector banks. If there are economies of scale in banking, and presumably one would want to avoid undue concentration of capital in the private sector, it would create problems for regulation. So, is there an intermediate option between the two extremes?

Mridul Saggar complimented the authors on the paper, and said that this is exactly what a public policy paper should be like because it has thrown up a range of issues. He said that the paper also offers the solution upfront, which is to go radical. He reiterated the question raised by Ram Singh, which is basically whether it is the size or the scale and scope of economies, which may be one of the reasons as to why SBI stands out among the other public sector banks. As regards the reasons that take SBI closer to private sector banks in terms of performance, it is very clear that there are more positive government interventions in the case of SBI as compared to other public sector banks. Whether it is infrastructure or priority sector landing or food credit, for instance, that whole consortium is largely managed by the SBI, which is unable to invoke the government guarantees because the government is the owner. Therefore, it is important to analyse as to why a single public sector bank is the best solution and not the consolidation of a few public sector banks because in essence, if the scale and scope economies are driving a better solution, it might be prudent to retain a more competitive structure. Albeit, the private sector banks can offer competition but if the few public sector banks can be consolidated and can offer an alternative optimal model for the financial sector reforms, this is something that an extension of the paper could probably establish. He also said that governance is still the key to the future of banking, especially the public sector banks. This paper suggests a number of solutions but if the government had heeded the P. J. Nayak Committee Report of 2014, these questions would not have lingered. The P. J. Nayak Committee Report had clearly argued for repealing of the Nationalization Act and the SBI Associates Act for bringing down public sector ownership below 50 percent. He concluded that regulators are important but the issue is not whether there is a single regulator or multiple regulators but whether the regulator has the power to deal with the situation or not. The supersession of the board is a very essential power which a regulator should have.

Replying to the comments, Arvind Panagariya said that it is important to state the criteria for qualification of who can be given a banking license. He said that perhaps midway could be a solution, that is, maybe some of the public sector banks, not all of them, could be merged into SBI, and some of the remaining ones could be privatized. On the issue of conflict of interest, this is a focus paper on some specific set of issues. There is one conflict of interest, which comes from the ownership by the government of the banks, which led to all the crony lending that happened 2008 onwards or even earlier actually. That conflict will remain as long as the banks remain. He suggested that the current momentum towards privatization should be capitalized upon.

Ashwini Kumar Tewari argued that SBI is the largest lender to everyone, not just to specific corporates or groups, and SBI is the largest everywhere simply because it is the largest in the system. As regards the checks and balances, the regulator has put in a lot of checks and balances. One is the large exposure framework where the bank is not allowed to lend beyond a particular level of its capital reserves. And gradually the idea is to bring all the larger groups and the larger exposures towards non-bank finance, which is bonds and equity. This is work in progress because for many of the larger groups, if all the banks are prohibited to lend, then there would be a challenge from the market absorption point of view also. SBI's lending book is upwards of Rs 25 lakh crores, whereas the lending to any of these groups is not even Rs one lakh crores. So, the bank does commercial lending on merit, not the name of the borrower.

The Chair, Manish Sabharwal, asked if SBI would agree to all nationalized banks being merged into it. Ashwini Kumar Tewari responded that such a merger would create a much larger entity, which would be a huge concentration risk. He suggested that the next 2-3 larger banks could perhaps be combined and reach a market share of, say, 15 percent. He also pointed out that the period from 2015 till 2019–20 was a really traumatic period for banking, especially for public sector banks, because of the NPA overhang and various other issues. Therefore, the government's entire focus was on resolving the issues and all the steps taken were focused on this resolution rather than on structural reforms.

Ruchir Agarwal asserted that SBI is too big to fail, and there is a need for much more intrusive powers for supervisors. He emphasized the need for a community of scholars, thinkers, and policymakers working on macro-financial issues in India because the welfare importance of this issue is much more than many of the other issues currently being examined by academic economists.

Poonam Gupta said that regarding the intriguing issue that Dilip Mookherjee raised on consolidating the rest of the public sector banks, SBI is already too big to fail. If one were to recall, during 2009–10, some of the private banks actually faced deposit withdrawals and all those depositors went to the SBI because SBI is considered to have the strongest implicit deposit guarantee. So, if we were to make that bank nearly 60 percent of the entire banking sector, what could that do to destabilize everybody in the market? Ruchir Agarwal mentioned that

there is heterogeneity within private banks. Four of the top private banks are doing very well. Why do we not allow them to become larger, whether you call it privatization or whether you call it merger of poor performing public sector banks with some of the best performing private banks so that they also become about 8, 10, and 12 percent of the total banking sector? She stressed on the adoption of such an approach.

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ANUP MALANI*
University of Chicago

Lessons from Disease and Economic Surveillance during COVID in India§

ABSTRACT This paper describes disease and economic surveillance during COVID, along with the uses of that surveillance, and lessons learned about the pandemic from that surveillance. It ends with policy suggestions on how to gather intelligence during the next pandemic in India and how surveillance informs suppression policy. The important themes that I stress are the value of population-level surveillance, understanding the incentives and disincentives for surveillance and reporting, and tailoring policy to the results of surveillance.

Keywords: *SARS-CoV-2, Surveillance, Disclosure, Poverty, Inequality*

JEL Classification: *I10, I14, I15, D82, D83*

1. Introduction

Chinmay Tumbe, in his book *The Age of Pandemics*, argues that India has historically been hit harder than other countries by pandemics (Tumbe 2020). For example, India lost more lives to each of cholera, the plague, and the 1918 flu than other nations.

COVID may provide additional evidence for his hypothesis. Officially, India has 34 million cases and 500,000 deaths. The actual cases and deaths are likely much higher. Serology suggests that 90 percent have antibodies, though some of that is due to vaccination. Estimates of excess deaths suggest that 5 million or more may have died. The economy also took a hit. Poverty spiked during the pandemic and remained elevated after the national lockdown.

* *amalani@uchicago.edu*

§ The author thanks Artha Global leaders Reuben Abraham and Pritika Hingorani for facilitating all his work done with Indian governments during the pandemic; researchers such as Manoj Mohanan, Anu Acharya, Satej Soman, Arpit Gupta, Gayatri Lobo, Jayanti Shastri, Sandeep Juneja, Sofia Imad, Ullas Kolthur-Seetharam, Jake Kramer, Neelanjan Sircar, Sam Asher, Paul Novosad, Mudit Kapoor, Sudharshini Subramanian, and Vaidehi Tandel for their collaboration; Jon Gruber, Lius Bettencourt and Ashish Goel for their support and guidance on public health work in India; Emergent Ventures leaders, Shruti Rajgopalan, Alex Tabbarok and Tyler Cowen for their support; and the University of Chicago for enabling him to work substantially on Indian public health projects since 2020.

Are there lessons we can learn from India's experience during COVID that might help the country better handle the next epidemic, whether it is Monkeypox or pandemic flu? In this paper, I review India's response to the pandemic, discuss several efforts to track the spread and consequences of the pandemic, and explore implications for how to handle pandemics.

The paper has four substantive parts, corresponding to stages of the epidemic and India's policy response: before the pandemic reached India, just before the lockdown, during the lockdown, and after the lockdown. (I stop before vaccination as the paper is already quite long.) In each section, I discuss surveillance strategy and associated policy response. Each of my discussions tries to answer four questions: What did the government do? Why did it do so? What were the consequences? and What should the government have done differently?

There are a few broad lessons and reforms that I highlight. First, policy should consider both individuals' and governments' (imperfect) incentives to test for infection, to report test results, and to act to stop infection. Likewise, the government should keep an eye out for unintended consequences of policies like quarantine. Second, the government should build a disease and economic surveillance infrastructure and commit to regular reporting, even before a pandemic. When doing so, it must take sampling seriously, not make strong assumptions about the nature or course of disease, stock necessary supplies and expertise, eliminate obstacles to testing, and learn how to interpret different types of tests. Third, the government should think carefully about institutional design and ensure that agencies are neither overwhelmed nor have conflicting incentives. Fourth, the government should connect disease surveillance to economic data so as to facilitate interpretation of the latter. Likewise, it should ensure that policy is updated based on disease and economic surveillance, otherwise, surveillance has less value and policy can go awry.

Before proceeding, let me issue a caveat. I will often criticize the government for having done this or that. However, the Indian government is not a unified entity. There are battles between the executive (say, the office of the Prime Minister or a Chief Minister) and bureaucratic agencies, as well as between agencies and between the Centre and States. When some arm X makes a decision, perhaps in error, there will be some other agency or political actor that will attempt to change or redress that decision. Moreover, the Indian Government is not at all unique for not handling the pandemic perfectly. Similar criticisms can be heard of governments around the world, including those of the US, UK, Sweden, China, and Australia. This is not to excuse bad decisions, but to suggest that the COVID pandemic is a teachable moment for all countries. The goal should not be to cast blame but to make changes and better prepare for the next pandemic.

2. The Pandemic Reaches India

COVID officially reached India in late January, ostensibly in Kerala (Andrews et al. 2020). Whether these were the first cases, we will likely never know. We did not immediately have a large number of tests for COVID, and, in any case, they were not immediately deployed to screen all or a random sample of travelers.

How could India have detected COVID earlier and would that have made a difference in its response? India's best early warning system is other countries' reporting of outbreaks: this provides signals of a threat before it reaches India's boundaries.

2.1. Foreign Surveillance

The problem with foreign surveillance is that each country has little incentive to reveal a pandemic within its boundary (Malani and Laxminarayan 2011; Laxminarayan et al. 2014). Doing so triggers travel and trade restrictions.[1] The WHO tries to change incentives by providing medical expertise and resources. But this benefit has little value for countries that already have great health care capacity. It is not surprising then that China may have delayed the announcement of COVID (Watt 2020) and did not fully cooperate with WHO efforts to identify the origin of the virus. Unless an outbreak originates in a country that has automated surveillance that the government has no discretion to censor or in a country that needs and values WHO assistance, relying on foreign surveillance is unlikely to be effective.

Even if disease testing is conducted by the WHO, one should not expect perfect reporting of outbreaks. This is not because of technical limits of testing, but incentives. Surveillance by the WHO depends on countries allowing the organization into their country. If the WHO's tracking was too sensitive, then countries at high risk of disease outbreaks would not permit WHO testing. Doing so would be equivalent to always disclosing outbreaks immediately. As we noted above, sometimes the costs of sanctions are greater than either the medical support from the WHO or the country's altruistic desire to help the world community. The WHO is surely aware of this. So, it rationally has to tolerate a country's efforts to delay or suppress information on outbreaks to ensure that it at least obtains some information on that outbreak. The alternative might be even less information on outbreaks.

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1. A related problem I encountered later in the pandemic and within India is that governments may not want to test if the results from testing will force it to adopt a policy that it does not prefer. Officials from a State that I will not name informed me that the State was not eager to test for COVID because doing so would reveal a high level of cases that, in turn, would cause the press to demand a lockdown. Politicians, whose supporters cared not just about population health but economic output, did not want a lockdown. But the politicians predicted that they would not be able to resist press calls for a lockdown without paying a very high electoral cost.

The last two paragraphs contain bold—and politically volatile—claims. But they reflect both the logic of economics and diplomacy. Imperfect incentives for testing are a reality, and we will also see this play out domestically, with testing efforts within countries, including India. An important challenge for pandemic policy is to create incentives for testing and reporting outbreaks. But until that is accomplished, India should not rely on early warning of outbreaks by foreign countries.

2.2. Response to Early Warning

Although the world may have received delayed signals of the COVID outbreak, it did receive those signals. Did countries act immediately when they ultimately received evidence of outbreaks? For the most part, no. For example, India did not act until cases reached its shores.

This delay is unsurprising, and behavior that was not unique to that country. Indeed, tardy response to threats is both rational and should be expected in the future. A country receives many warnings about potential disease and non-disease risks (such as climate change, economic threats, and security threats). However, the country has limited resources and cannot act decisively on each risk. Moreover, some risks turn out not to be serious. It must choose amongst threats based on some assessment of their expected harm.

Many people will argue that governments were warned about COVID. Famously, Bill Gates had been warning of the risk of a pandemic for years. But that is true about nearly every major calamity and—importantly—many non-calamities. How do governments determine which threats are worth acting on, and which are not? Ex-post evaluation after a disaster is unhelpful because it provides an incomplete picture. India did not act early on COVID, and in hindsight that was a mistake. But India also did not act early on SARS, and in hindsight that was not a mistake.

Experience with prior crises suggests that countries use actual harm as a way to distinguish between credible and non-credible threats, between threats to which they will and will not respond (Malani 2009). We have seen this over and over, with the Asian Tsunami, the 2008 financial crisis, Mumbai terrorist attacks, and now COVID. The result is that governments (rationally) fail to take preventative action and appear to be caught flat-footed.

The implication is that we should expect the same next time around. Early warning of a pandemic is insufficient to trigger a response. Surveillance will reveal many risks, but not all will be credible risks, until they reach India's shores. Therefore, surveillance is a necessary, but not sufficient condition for early action. However, it will prove useful once a threat has arrived and the government is compelled to act. Specifically, it will help the government gauge the significance of the threat and the efficacy of its response. In addition, it will assist individuals, who may be more risk-averse or credulous than the government, to take private actions to protect themselves.

2.3. Travel Restrictions

Background. The Central Government's initial response to the pandemic consisted of a series of travel restrictions. India was not unique in responding this way: most countries did. The government restricted travel to India from high-risk countries, and then from all countries. It later restricted travel across States.

Travel restrictions are one stop along a continuum of movement restrictions. Movement restrictions have three components: Who, what, and where. Who governs the class of people governed by a restriction? What governs the extent of the restriction: what movement is restricted? 'Where' tells us the span of the restriction: what is the area over which it applies?

Travel restrictions cover a large area: a country or state. The restriction applies to all persons; however, there is a period of adjustment wherein residents and foreigners are eventually allowed to enter and leave, respectively. Finally, travel restrictions typically only restrict entry and exit from jurisdictions such as the country or state.

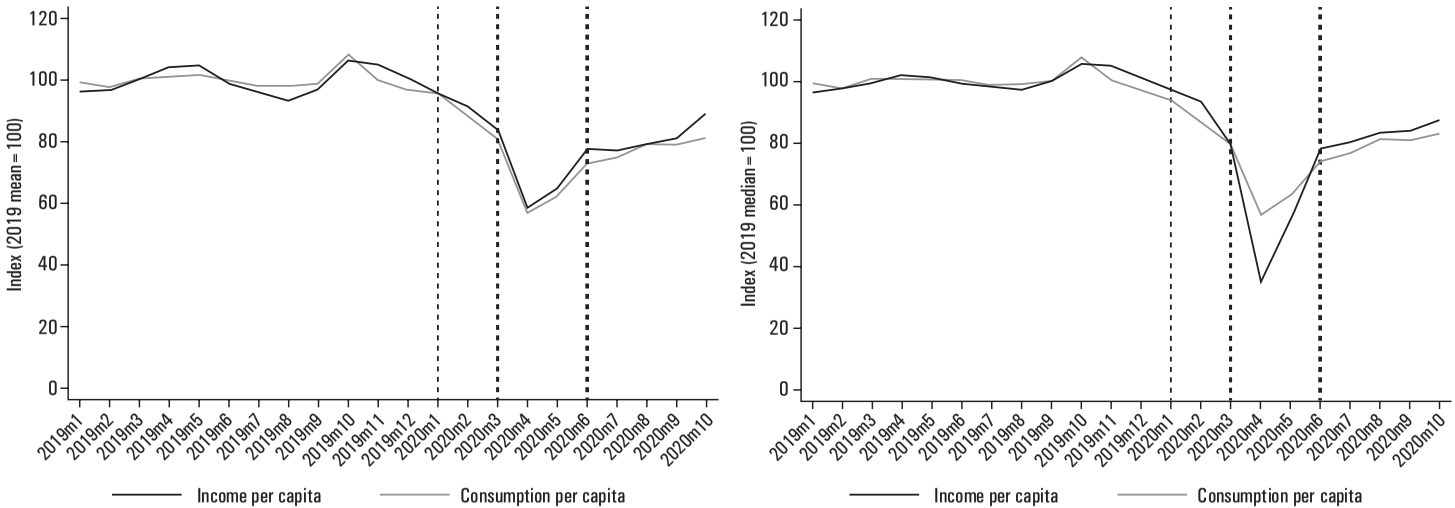
In contrast, lockdowns, containment zones, and quarantines have a bigger "what": they more sharply restrict movement within an area, for example, limiting the reasons for which a person can leave their home. The difference between lockdowns, containment zones, and quarantines is in their "where": lockdowns apply to a larger area (say, a whole district or larger area) than containment zones, which apply to a larger area (say, one or more city blocks) than quarantines (which apply to a home or even a room in a home). India used these measures once the pandemic reached its shores, and I shall discuss their efficacy below.

Implications. Casual—rather than causal—analysis suggests that travel restrictions—India's initial response—are unlikely to be very cost-effective, that is, their benefit in terms of delaying the spread of infection is smaller than the extent to which they harm the economy.

Travel restrictions are of limited value in controlling epidemics. Empirically, they did not prevent the infection from reaching any non-island country. India has limited State capacity to keep people out. Politically it is difficult to lock citizens out because they have connections and thus advocates at home. Moreover, travel restrictions are a blunt tool. They do not discriminate between safe and unsafe travelers, especially at the beginning of a pandemic when testing is scarce.

At the same time, economic surveillance during the pandemic suggests that travel restrictions may have substantially impacted incomes (Figure 1). Data from the Consumer Pyramids Household Survey suggests that mean and median incomes fell even before the national lockdown in March 2020 (Gupta et al. 2021b).

FIGURE 1. Time-series of Mean and Median Income and Consumption and Poverty, 2019–20



Source and Note: Figure and notes copied from Figure 2 in Gupta et al. 2021b. The figure was constructed by first dividing the household income by the household size to calculate per capita income, then dividing by the State x urban status specific mean or median 2019 income, and finally calculating monthly means or medians using individual member weights. A similar process was followed for consumption. Dashed vertical lines in January 2020, March 2020, and June 2020 indicate the month of first case (left vertical line), the month the national lockdown started (middle vertical line), and the month the national lockdown ended (right vertical line). All values are inflation-adjusted in 2012 INR.

Perhaps there were collateral benefits of travel restrictions. They signaled to Indians two things. First, the government was on the case. That sort of reassurance may be important for maintaining allegiance. Second, it may have signaled to people that worse restrictions may come, and they had better begin to adapt. I suspect this is the reason that there was a surge in migration out of cities even before the surprise announcement of the national lockdown.

Be that as it may, going forward one should be aware that travel restrictions are an incomplete solution. At best they reassure the public and buy time for a more thoughtful response.

3. Early Surveillance within India

3.1. Symptomatic Surveillance

Background. Initially, surveillance for COVID took place in hospitals, focused on symptomatic individuals, and looked for viral fragments in sampled sputum. This strategy was not uncommon around the world.

Testing of symptomatic individuals in hospitals reflected a medical doctor's mindset. A medical doctor conducts diagnostic testing on patients that come to her with some indication that testing is warranted. She does not test seemingly healthy individuals in the community. That strategy makes sense for non-communicable diseases. A demand-pull strategy respects a need both to allocate scarce resources and for patient consent. But it is inappropriate for communicable diseases, especially when asymptomatic transmission is possible. Externalities from illness may warrant a supply-push strategy where the government conducts testing to assess the extent of risk from infected (though perhaps asymptomatic) individuals to uninfected individuals.

Implications. Initial focus on symptomatic cases in hospitals meant that surveillance missed asymptomatic cases in the community (Thacker 2020). In hindsight, we know that perhaps 90 percent of infections were asymptomatic, even early in the pandemic (Kumar et al. 2021). As a result, either the government had incomplete information, or the government did not prepare the population for the coming storm. If the government did not know the extent of community spread, it may have led it to both under- and over-reacting to the pandemic. At the start, it did not warn individuals to self-protect. Then, the government, perhaps due to alarmist forecasts from disease modelers, did a 180-degree turn and implemented one of the harshest lockdowns the world had seen.

Bihar conducted a study in spring 2020 that suggested a potentially large gap between surveillance at hospitals and surveillance in the community. Specifically, the State randomly sampled people from trains with migrants returning to Bihar from States across the nation after India's national lockdown was lifted in May and June 2020. Table 1 reports the infection rates reported in

TABLE 1. Difference between Positive Test Rates among Returning Workers and among Residents of State, by State or Territory of Origin and Time Period in 2020 (Percent)

State	*(1) May 4-May 21*		*(2) May 22-May 31*		*(3) June 1-June 10*	
	State-Reported Positive Rate	*Difference*	*State-Reported Positive Rate*	*Difference*	*State-Reported Positive Rate*	*Difference*
Andhra Pradesh	0.5	0.6*	0.6	5.3***	0.9	2.2***
Chandigarh	6.7	3.9**	5.9	2.3	4.7	0.7
Chhattisgarh	0.3	3.5***	1.5	2.5	3.0	3.0
Delhi	7.5	5.8***	14.3	1.8**	24.6	11.8***
Gujarat	8.7	3.0***	8.9	0.0	8.6	0.5
Haryana	1.0	6.0***	3.8	7.0***	8.4	3.7***
Jammu & Kashmir	0.9	6.8***	1.7	2.8	2.9	3.4
Jharkhand	0.7	0.5	1.3	2.9***	2.9	3.4**
Karnataka	1.0	0.7*	1.4	6.1***	2.5	2.1***
Madhya Pradesh	4.1	0.9	5.0	0.7	3.2	0.1
Maharashtra	17.4	7.8***	18.1	0.0	18.8	9.5***
Odisha	1.4	0.7	2.0	0.8	3.9	3.9**
Punjab	2.6	0.5	0.9	3.9***	0.9	4.0***
Rajasthan	2.2	0.9**	1.9	3.1***	2.1	2.7***
Tamil Nadu	5.0	0.5	7.1	0.2	9.8	6.1***
Telangana	-	-	-	-	-	-
Uttar Pradesh	2.5	1.6***	3.1	11.4***	3.0	7.1***
Uttarakhand	0.8	0.8	5.2	0.0	6.9	4.9
West Bengal	2.2	4.6***	2.6	1.7*	4.2	0.4
Total	4.5	1.8***	5.5	5.6***	6.4	2.4***

Source and Notes: Table and notes have been reprinted from Table 3 in Malani et al. (2020a). Statistics for States from which testing results are not available are marked as missing. For some States, the dates for the test result data do not correspond exactly to the dates of each of the three periods; in those cases, we take data for the closest period corresponding to each of the three periods. The State-reported positive rate is the number of confirmed cases reported by a State divided by the number of tests conducted by that State during the relevant time period. Asterisks (*/**/***) are used to mark statistical significance (at the 10/5/1 percent level).

each State during three periods and shows the degree to which the State-reported rates fell below rates estimated with random testing on returning trains. The average under-estimate ranged from 1.8 to 5.6 percentage points. This implies that the actual rates of infection might be perhaps 40 to 100 percent higher than the official estimates. It is possible that migrants, who come from dense slums, have a higher rate of infection, a topic to which I will return later. It is unlikely, however, that Bihar's estimates reflect infection on crowded trains

because infections caught on trains were unlikely to be detected upon arrival when testing was conducted.

Reforms. A better approach would have been to understand that infectious diseases are better handled as a public health rather than private health matter. That requires both testing symptomatic patients and testing a representative sample of the population. The latter would have revealed the extent of community spread. Community surveillance should also have been done repeatedly so the country could learn both the level of infection and its rate of spread.

Switching from a therapeutic to public health posture may require institutional reforms. In India, the National Centre for Disease Control (NCDC) resides in the Ministry of Health and Family Welfare (MoHFW), much as the CDC is technically part of the U.S. Department of Health and Human Services. However, at the start of the epidemic, the COVID war room was set up in the MoHFW and, instead of the NCDC, the Indian Council of Medical Research (ICMR), played the central surveillance role. That the war room was in the MoHFW is unsurprising: the scope of the epidemic required an entity that also managed the country's health care facilities and drug approval system. What was surprising was ICMR's displacement of NCDC in testing strategy as ICMR was mainly a research entity before the pandemic (Mookerji and Chitravanshi 2021). This research mindset may have slowed down testing as academic organizations tend to be conservative to preserve their scientific credibility. Yet what was required at the start of the pandemic was a bias for action, in this case, on testing. It is true that NCDC needed strengthening, both in terms of resources and personnel. (And the same is true about the US CDC.) But the COVID pandemic could have been a critical growth and learning opportunity. Going forward, it would be prudent to strengthen NCDC and use that entity as a platform for disease surveillance.

3.2. Viral Testing

Background. At the start of the pandemic, testing employed real-time reverse transcription-polymerase chain reaction (RTPCR or PCR) techniques that amplify viral fragments in biospecimens to facilitate the identification of those fragments. This revolutionary technology has been used to identify past viral infections such as SARS, another coronavirus. It is unsurprising that this technology was the first deployed to test for ongoing COVID infection.

Implications. PCR testing has both advantages and disadvantages. The main advantage is sensitivity. PCR tests on nasopharyngeal swabs have a clinical sensitivity of roughly 80 percent. (Laboratory accuracy is even higher, but clinical accuracy, which accounts for sample-taking errors, are more relevant for practice. RTPCR tests are more sensitive than rapid antigen tests, which emerged later in the pandemic.) RTPCR tests are also highly specific when compared to tests on samples with no prior infection or infection with other coronaviruses.

The main disadvantage of RTPCR is that it is not very specific for ongoing versus cleared infection. Because RTPCR looks for viral fragments, it may give a positive result even after the immune system has overcome a COVID infection. Just as there may be dead soldiers on the field after a battle, there may be viral fragments in sputum after a successful immune response. This affects the interpretation of RTPCR positivity rates and infection rates.

A further problem with RTPCR is that it measures flow rather than the stock of infection and does not clarify the risk from that flow. Let us assume away for a moment that the government had conducted RTPCR tests on a representative sample of the population, notwithstanding the discussion in sub-section 3.1. Even then, RTPCR provides an imperfect measure of future risk. The reason is that it provides a measure of the fraction of the population that is currently infected, but the risk that that number poses depends on how many people were infected in the past.

This logic is best illustrated in the context of a susceptible-infected-recovered (SIR) compartmental model. Although the SIR model may not be appropriate to use when a virus mutates, it is insightful in the short run before a new variant arrives and helps illustrate a problem that is shared by models that account for viral evolution. The basic equations that describe this model are given below.

$dS/dt = -bSI$

$dI/dt = bSI-gI$

$dR/dt = gI$

where S is the fraction of the population that is susceptible to infection, I is the fraction that is infected, R is the fraction recovered, b is the transmission rate, and g is the recovery rate.

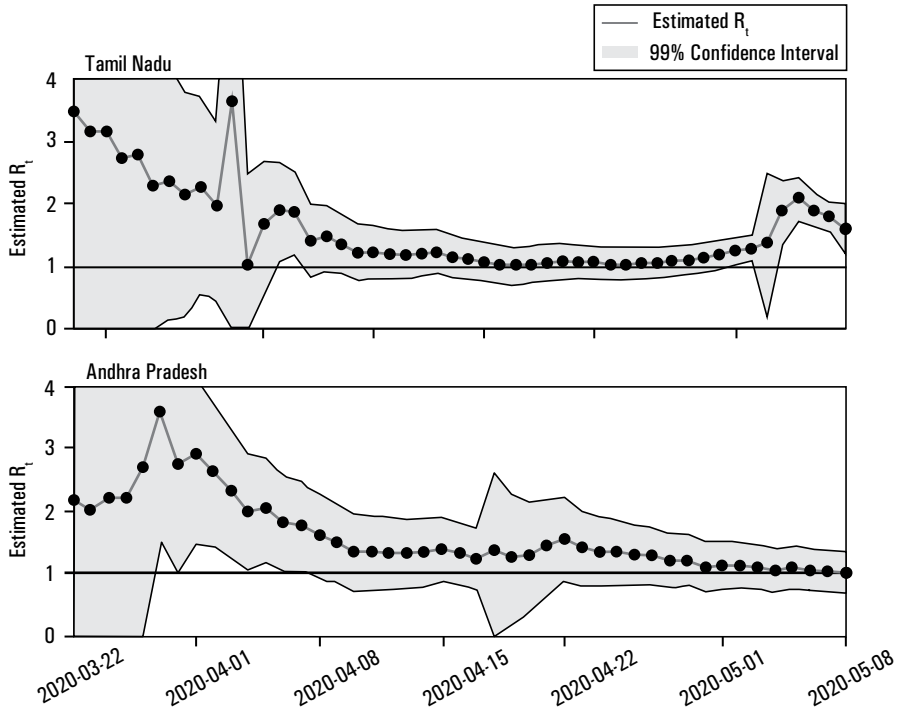
The key insight of this model is that the (basic) reproductive rate of the infection at the onset of the epidemic is $R_0 = b/g$, but as the epidemic progresses the (current) reproductive rate becomes bS/g, which falls with S as the epidemic progresses. Intuitively, the number of people an infected person can herself infect increases in the number of people who are susceptible. The number of susceptible persons falls as an epidemic progresses, so the risk from a given level of infection falls with time. To get a more accurate measure of risk requires knowledge of the fraction of people who remain susceptible. That is equivalent to 1 minus the fraction of people who are currently infected and the fraction that has recovered from infection. The fraction recovered is proportional to the number of people who were previously infected, i.e., the stock rather than the flow of infected.

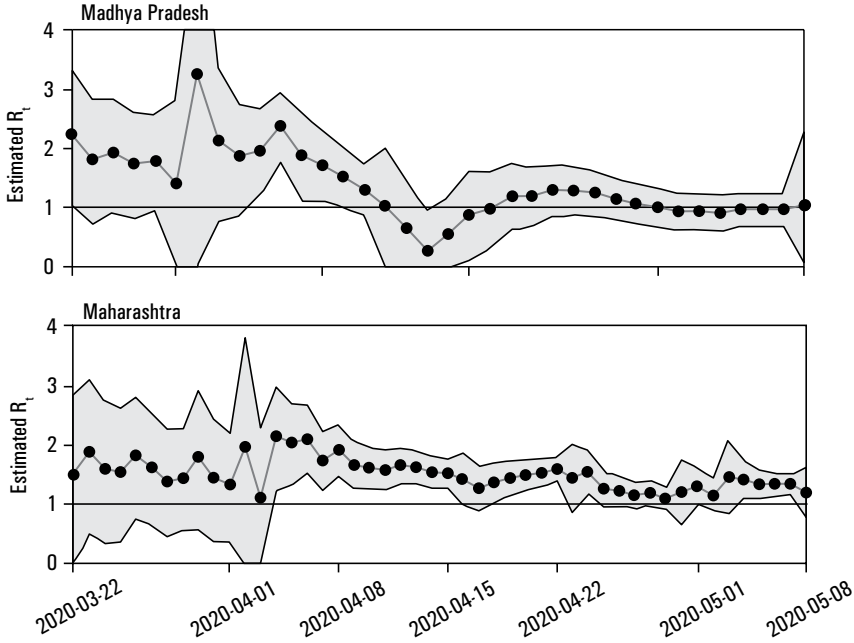
One might suspect that one can simply examine the trend infection rates to glean future risk. To some extent that is true: in an SIR model, infection rates look like a bell curve, with the level of risk from a given level of infection depending on whether one has reached the peak of the infection rate curve or not. The problem is that the SIR model is a useful tool for understanding the logic of infection but does not accurately describe reality. First, the SIR model

motivates policies such as lockdowns, which are thought to "flatten the curve" and buy time for building hospital capacity. But this very flattening complicates the identification of the peak of the infection curve. Relatedly, the SIR model does not account for human behavioral responses. Economists have shown that incorporating individual precautions into an SIR model causes a flattening of the infection curve just as a lockdown might (Toxvaerd 2020; Gans 2022 #5538). (I will explore this model in subsection 3A.) Second, the SIR model is appropriate for a non-mutating virus. But SARS-CoV-2 does mutate and at a rapid clip. In that scenario, there is a future risk of a jump in infection rates even if the infection rate is currently trending downwards.

Reforms. Two things can address the shortcoming of measuring current infection rates. First, one should couple estimates of infection rates with a model of infection that allows one to measure current reproductive rates. Using this approach, one can use past infection rates and an assumption about the recovery rate g to estimate current reproductive rates. Along with colleagues such as Satej Soman, Luis Bettencourt, and Vaidehi Tandel (Malani et al. 2020c), I used this approach to provide estimates of district- and ward-level reproductive rates to various Indian jurisdictions during the early course of the epidemic (see for example Figure 2).

FIGURE 2. Estimated Reproductive Rate, by State





Source and Notes: Figure and notes are taken from Figure 3 in Malani et al. (2020c). Data range from 11 March 2020 to 11 May 2020. Code and files available at https://github.com/mansueto-institute/ covin-c2-adaptive-control-wp.

Second, one can more directly estimate the number recovered by estimating the prevalence of anti-COVID antibodies or cellular immunity to COVID. That would enable a direct adjustment to the basic reproduction number to obtain the current reproduction number and forward-looking estimate of risk in different locales. I will discuss serological surveillance and cellular immunity later in this paper.

3.3. Cases versus Positivity Rate

Background. From the very beginning of the pandemic, the government has reported the number of positive tests. To convert that into an infection rate, a more informative statistic for both epidemiology and policy, one needs to have a denominator. A tempting approach is to divide by the number of tests conducted. This was not always easy to obtain, as testing rates were not always reported by the government. But even when they were, they did not always produce a useful measure of infection rates.

It is possible that the government did not report testing rates because they did not track them. In the rush of the pandemic, perhaps only the most important administrative tasks were required. Perhaps this prioritization required a positive test to be reported, but not a negative one. As a result, testing rates

were scarcely reported at the very start of the pandemic. One can see this by examining data on testing rates prior to June 2020 on www.covid19bharat.org.

Even after testing rates began to be reported, it was not easy to estimate infection rates because testing was not random. As mentioned above, testing focused on symptomatic individuals, who were more likely to be infected. Thus, the positivity rate was possibly an overestimate of the infection rate. At the same time, the positivity rate was used to inform the testing rate. If the positivity rate got too high, officials demanded more testing. If the targeted positivity rate ended up below the actual infection rate, testing might yield an underestimate of the infection rate. In any case, when sampling is conditioned on the outcome of sampling, sample statistics are not unbiased for population parameters.

Reforms. Perhaps the best that can be done under these circumstances is to, first, ensure testing rates do not depend on testing outcomes. To the extent they must, they should do so only periodically, and changes should be announced so that estimates do not accidentally mistake attribute changes in testing rates to changes in infection rates.

Second, though non-random sampling means that one cannot obtain unbiased estimates of the infection rate, one might be able to obtain, for short periods, reasonable estimates of the trend in the infection rate. Specifically, if (a) during some interval the testing rate and the testing policy is unchanged, and (b) it is reasonable to assume that trends in the sampled and unsampled population (e.g., among symptomatic and asymptomatic people) are the same, then changes in the positivity rate are informative about changes in the infection rate in that interval. The first assumption motivates the policy recommendation in the last paragraph. The second assumption is not unreasonable if the probability of whether a person is symptomatic does not depend on whether the person who infected her was symptomatic and the fraction of infected persons who are symptomatic is constant over time. These conditions seem to hold for a given COVID variant.

Third, it is important to keep track of and report testing rates from the start of the pandemic. While this seems a trivial reform, it is hard to implement because the government may be loath to admit that it has a low testing rate at the start of a pandemic. The solution may be to build a peacetime testing infrastructure that would enable a reasonable rate of testing from the very start of a new pandemic.

3.4. Communication Policy

Background. India's initial, hospital-focused testing strategy may have reflected a desire to contain panic (Kurian 2020). The government repeatedly announced that there was no community transmission (Thacker 2020), when hindsight tells us this was false. These blinders-on and risk-minimizing strategies are typical for governments: information is controlled because it is assumed that the public will respond inappropriately to a threat. This tendency

is evident not just in testing policy, but also in how the government controlled (i.e., delayed disclosure of) information from ICMR's serological surveys and about the quality of the COVAXIN vaccine.

This tendency to avoid transparency is problematic for four reasons. First, it presumes that the governments make good policy decisions. The large variation in policy response to the pandemic—compare the response of the UK to that of Sweden, of the United States to that of Australia and China—suggests that all governments do not always act optimally.

Second, it assumes that the public does not act responsibly on information about social risks. This is contradicted by experience. For example, empirical evidence suggests that lockdowns have not had much of an effect because individuals engage in voluntary social distancing even absent government lockdowns (Goolsbee and Syverson 2021). To be sure, there are many other examples, such as masking and vaccination, where the public does not seem to take adequate precautions. However, some of the public's behavior can be written off as a difference in risk preferences of public health officials and the public: public health officials value health more and economic activity less than the public.

Third, while it could be argued that the public does not fully internalize the infection externalities from its risk-taking, the government's incentives may also be imperfect. Governments will argue that they want to control information to limit panic. But controlling information also allows them to limit criticism of their policy response to the pandemic.

The most important reason to avoid censoring information, whether by not testing or by withholding results from testing, is that the public will come to distrust the government's statements. Whether due to investigative reporting by journalists or the inability of the government to forever hide reality, the public learned the true nature and extent of the pandemic. Once that happened, it is likely that the public inferred either that the government was poorly informed or that the government misinformed the public. Both inferences reduce the future credibility of government officials. That, in turn, means that future communications policy and crisis response may be less effective.

Reforms. To remedy public skepticism about government announcements concerning the current and future pandemics, the government should commit to real-time data gathering and disclosure of evidence about epidemics. It can do so in two ways.

First, it should announce a surveillance strategy and promptly and regularly release information obtained from surveillance. This strategy could be as simple as reporting (self-selected) hospitalizations and deaths or as complicated as conducting regular surveys of representative populations, as Tamil Nadu has done (Selvavinayagam et al. 2021). Moreover, it should provide regular and detailed data from its public data. It can take a cue from efforts such as covid19india.org and covid19bharat.org. Indeed, it is an indirect slight against

the government that people rely on private efforts such as these websites (along with Johns Hopkins and Our World in Data), rather than governments or the WHO to track COVID. The advantage of regular and timely release of information is that individuals would know as soon as the government delayed a report that the government may be censoring information. Precisely because that delay would be so public, it would deter the government from interfering with data gathering or dissemination.

Second, the government should permit—even encourage—non-governmental and independent efforts to surveil for disease. These efforts could be by international organizations such as the UN or WHO, or from private companies and foundations. A good example, albeit of economic rather than health information, is the Centre for Monitoring Indian Economy's Consumer Pyramids Household Survey (CPHS). Even when ostensible data quality concerns and the pandemic delayed government economic surveys, CPHS continued to inform the public about the state of the economy. The independence of these organizations both increases the credibility of the information they provide and may increase the credibility of government data if the latter produce similar inferences as private data.

3.5. Contact Tracing

Background. A second important tool – besides testing symptomatic cases at hospitals – that the MOH used to track and contain the epidemic at its start was contact tracing. Contact tracing has its origins in the late 1800s, when infectious diseases spread in western European cities that grew dramatically at the dawn of the Industrial Revolution. Contact tracing is shoe-leather epidemiology: it requires the intuitions of a sleuth, not mathematic modeler. Individuals who test positive via, say, symptomatic surveillance, are asked about their contacts. Then health workers go out and interview and test those contacts. The process is repeated with each contact that tests positive. Each person who is positive is also asked to quarantine to limit the number of new infections they cause. (I will defer discussion of quarantining to the next subsection.) In this manner, contact tracing is ostensibly a method of measuring the spread of infection even as one controls the spread of that infection.

For slow-spreading and purely symptomatic infections, contact tracing can be an effective method of limiting an infection. But when the infection has a high reproductive number – the R_0 for even the wild variant of SARS-Cov-2 was 2 to 4 (D'Arienzo and Coniglio 2020) – contact tracing requires a massive, trained labor force and testing capacity, both of which are scarce at the start of an epidemic. Moreover, scarcity of testing means mainly symptomatic individuals were tested and quarantined. Asymptomatic infection escaped the net. In short, contact tracing is too slow to prevent the spread of a highly contagious infection.

Nor is contact tracing particularly effective at measuring the spread of an infection like SARS-CoV-2. From a statistical perspective, contact tracing employs a type of snowball sampling. But without knowing ex ante the process and rate of selection into infection, snowball sampling does not yield a representative sample and thus unbiased estimates of population parameters such as infection rates (Parker et al. 2019). Snowball sampling is even less effective when scarcity of testing (or misunderstanding about the infection) causes contact tracers to not test asymptomatic infections.

Reforms. That said, analysis of data from contact tracing efforts in Andhra Pradesh and Tamil Nadu did yield essential insights about the pandemic (Laxminarayan et al. 2020). The most important of these was that 5 percent of infections accounted for 80 percent of positive contacts (see also Endo et al. 2020). While most discussions of modeling COVID focus on basic or current reproductive numbers, this finding suggests need for focusing on the so-called dispersion factor k in the distribution of reproductive rates across individuals.

An important consequence of high dispersion is that policies targeted at populations, such as lockdowns, are less effective than individually-targeted interventions such as quarantines (Lloyd-Smith et al. 2005). Governments around the world—including in India—failed to heed this early warning, even though it was highlighted at the start of the pandemic (Kupferschmidt 2020; Lewis 2021).

High dispersion also means that it is critical to identify the observable correlates of superspreading: why are some infected people superspreaders while others are not? Yet, little of this analysis has been done. It was certainly feasible: health authorities in India could have sampled superspreaders and non-superspreaders, and carefully analyzed how these two groups differed, whether in social environment or biology. As far as I know, this work has still not been conducted (Lewis 2021).

Ostensible political obstacles to individual-focused policies should be easy to overcome with appropriate messaging. Perhaps equity is a concern: individual-based policies require treating ostensibly like people differently. But that ship has sailed and COVID policies already distinguish between infected and uninfected people, younger and older people, and vaccinated and unvaccinated people. Distinguishing between individuals who are more and less likely to be superspreaders seems a small additional step. Perhaps privacy restrictions are an obstacle. However, the high economic and liberty costs of lockdowns suggest that perhaps people would be willing to trade some privacy to permit investigation of individual correlates of dispersion.

3.6. Quarantine

Background. In the early and middle stages of the pandemic, the government required individuals to quarantine if they tested positive. Famously, Mumbai re-purposed a cricket stadium to quarantine individuals who lived in dense

housing that lacked the space for individual quarantine, i.e., individuals from slums (Express News Service 2020). The simple logic was that quarantining would limit the spread of infection.

While quarantine is a wise decision when all infected individuals are symptomatic and all symptomatic people are tested, it makes less sense when many of the infected are asymptomatic and testing is limited to symptomatic persons or when testing is voluntary. First, if asymptomatic individuals are not all tested for infection, there will be substantial spread of infection even if symptomatic cases are tested and quarantined.

Second, because quarantine is costly, even symptomatic people may avoid testing to avoid quarantine. As a result, many symptomatic persons will avoid quarantine and continue to infect the population. This is the same logic that leads countries to avoid reporting outbreaks: both governments and people will be deterred from obtaining information if that information entails a net cost.

One might argue that, on balance, quarantining is a good idea. Even if every infected person does not quarantine, the more infected people who do, the slower the disease will spread. Moreover, though quarantine may discourage some testing, there remains enough testing that quarantine slows the spread of disease more than a no-quarantine policy would.

Reforms. One could avoid the problem of discouraging testing if testing was on balance beneficial. Informing others may not be an adequate benefit because we are not all altruists. The typical reason for testing is access to therapy. However, until antivirals are widely available, therapeutics will not incentivize testing. Therefore, at the start of an epidemic, treatment is unlikely to incentivize testing (and thus quarantining).

An alternative benefit that could be used to encourage testing and quarantining is an exemption from lockdowns or mobility restrictions if one develops immunity. For example, if quarantining for ten days after a positive test provided a person a pass to circulate despite a lockdown or to travel between countries, that benefit might encourage testing. The problem is that governments were slow to grant immunity passports following natural infection. A reasonable concern was moral hazard: individuals might purposely infect themselves to obtain immunity passports. We do not have good evidence on either the extent to which quarantine deters testing or the extent to which immunity passports encourage infection. However, a fortuitous possibility is that quarantine will offset the incentive to become infected and immunity passports encourage testing.

4. The Lockdown

Roughly two months after its first COVID case, India suddenly announced one of the world's harshest lockdowns. It has been suggested that the government's

decision was informed by early models suggesting the pandemic would infect hundreds of millions in the absence of a lockdown. It is unclear that the lockdown avoided those infections. Moreover, in cities it may have accelerated infections.

4.1. Disease Modeling

Background. Early in the pandemic, there was very little empirical data about the pandemic. However, that did not stop modelers from combining that meager information with models of exponential growth in disease to project scenarios that ranged from tens of millions infected to nearly a billion people infected (see, e.g., Singh and Adhikari 2020; Chatterjee et al. 2020; Wang 2020). It has been asserted that this work motivated India's lockdown (Wikipedia 2022).

With the exception of Chatterjee et al. (2020), all the models were created by scientists working abroad. Within the government, early projections were often based on polynomial projections using Excel and data on positive cases. One reason for this reliance on foreign experts is that India does not have a deep bench of mathematical biologists working on disease models. When the pandemic hit, the shortage of mathematical biologists became a global problem. As a result, many of the early modelers – in India and abroad – were computer scientists (e.g., Sandeep Juneja), mathematicians (e.g., Murad Banaji), physicists, and economists (e.g., Mudit Kapoor), who had mathematical and simulation skills and could quickly brush up on the structure of epidemiological models.

Implications. Mudit Kapoor, working with NITI Aayog to evaluate these models, asked me for my evaluation of these models. I referred the question to a group of physicists and engineers at MIT, who tried to stress test the models. They raised two concerns (Figueroa et al. 2020).

The first was that some of the models were not transparent. They specified no equations or parameter values. To evaluate the credibility of models, one needs to know what goes into them. Without clarification about inputs, one could not be sure whether the model's output was credible or made up.

Second, the models were extremely fickle. Pandemic disease follows an exponential process. Small changes in parameters could have huge impacts on predictions. The median estimate of the basic reproductive number (R_0) for the original variant of SARS-CoV-2 was 3. That implies that each current infection would produce three future infections. But the range for the virus's R_0 was 2-4. Assuming a ten-day recovery, let us suppose new infections are generated in five days. Then in a given month, each infection could lead to either 64 (2^6) or 4096 (4^6) infections.

An important implication is that the error on forecasts rises with time. The error in one month out of four is the right R_0 but instead when two is used (or vice versa), it is roughly 4000 cases. Two months out the error is over 16 million! If we use a 1 percent death rate, the error is 40 deaths in one month but 167,731 deaths in two months. And all from just one infection!

Despite the extreme sensitivity of disease model forecasts, there was little surveillance and thus data to support the parameters plugged into the early models, and yet the models were used to make forecasts months out.

A third concern, raised by economists, is that none of the models considered the human behavioral response to the pandemic. The standard epidemiological model assumes that human behavior is unaffected by the occurrence of an epidemic. But that is false.

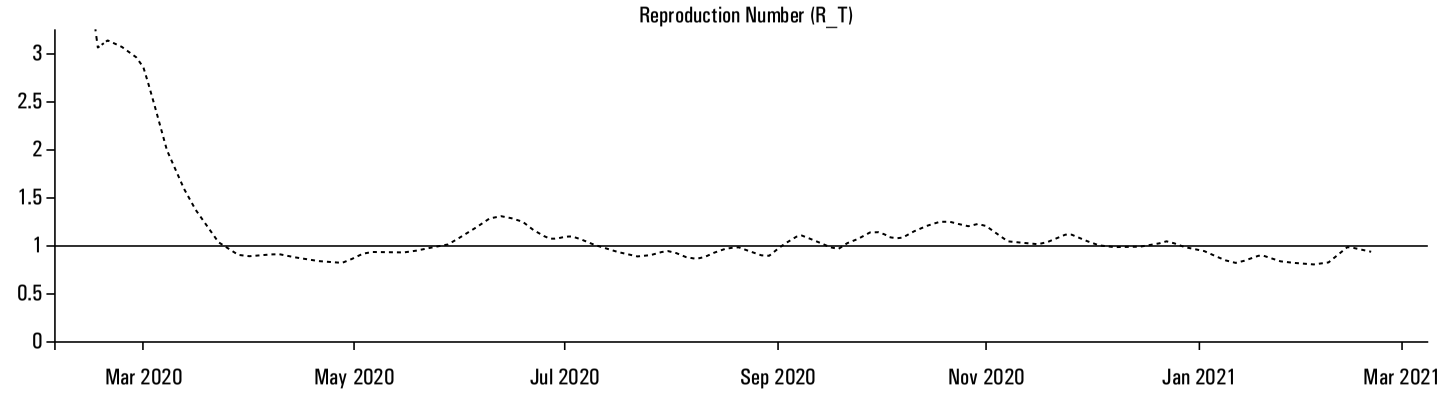
Individuals take precautions even when not forced to by the government. One piece of evidence is that, in the data on COVID, the current reproductive number (R_t) lingers at 1 for extended periods of time (even outside the context of a lockdown). See, e.g., Figure 3, using data from the US. The workhorse SIR model in epidemiology cannot explain this behavior.[2] (Nor can simpler Gaussian models. A susceptible-infected or SI model, can generate periods of R_t=1, but it has other problems, which I will discuss below.) But simple economic models that couple the SIR model with humans that choose activity levels to balance health and the benefits of activity do generate the prediction that R_t lingers at 1 (Gans 2022). Another piece of evidence is the failure of empirical work that adequately accounts for voluntary social distancing to find big impacts from lockdown (see, e.g., Goolsbee and Syverson 2021).

Once human behavior is included in the SIR models, the models predict that, instead of a single peak in infections, there is an extended plateau (Toxvaerd 2020; Gans 2022); see Figure 4. The epidemic runs through the population, but at a slower rate. When the susceptible population falls so low that bS/g falls below 1, the R_t in the economic epidemiological model also begins to fall. To put it another way, the epidemic will follow the same qualitative pattern without a lockdown as it would if a lockdown were imposed, that is, human response flattens the curve even without a lockdown. The main difference between a lockdown and human response is that the lockdown might flatten the curve at a lower level of infection. However, this merely delays cases.

Reforms. India's early experience with disease modeling suggests two reforms. First, it is important that the country invest more in disease modeling, both in the government and in academia. It is critical that the investment be such that there are multiple groups that can critique each other and, in the process, improve each other's work. In addition, disease modeling should be an interdisciplinary activity. Epidemiologists should work with computer scientists and physicists, on the one hand, and social scientists, on the other. The former group will improve the robustness and computational efficiency of the disease model. The

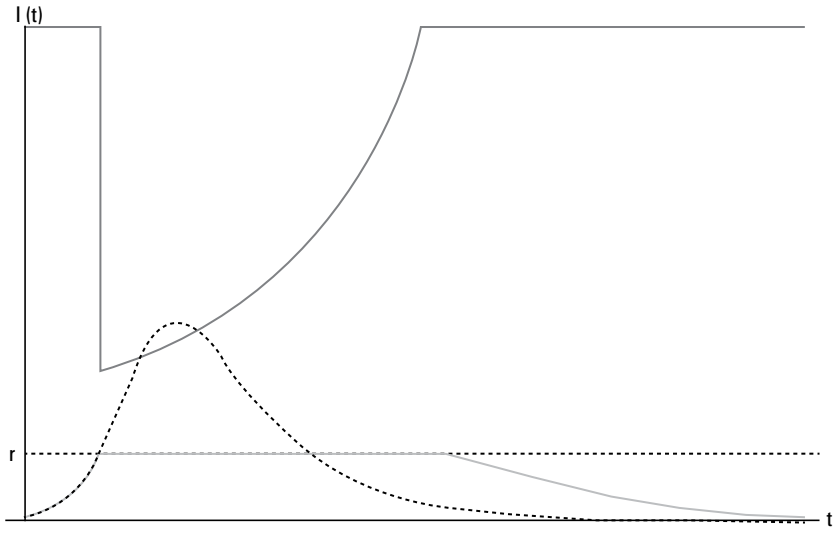
2. In a SIR model, R_t is equal to bS/g. The share of susceptibles S falls from 1 to some minimum level, perhaps 0, following a backward S curve. This implies that R_t passes through 1 but does not linger there. Even when S plateaus, R_t is not 1 because S only plateaus when I=0, so R_t is undefined.

FIGURE 3. Effective Reproduction Number (Rt) for United States, March 2020–March 2021



Source and Notes: Data cover 3 COVID-19 waves in the US. Rt estimates are based on deaths data. Figure is copied from Youyang Gu, https://covid19-projections.com/.

Figure 4. Equilibrium Disease Prevalence and Social Distancing across Stages of the Epidemic



Source and Note: This figure was generated by Flavio Toxvaerd based on Toxvaerd (2020). The dashed line shows infections in an SIR model without human behavioral response, the light grey line curve shows disease prevalence I(t) with voluntary social distancing, and the dark grey line curve shows exposure (1-d(t)).

latter group will help correct the biggest error in disease models, which is the failure to account for human behavioral response.

Second, disease modelers, and their government audience, should be more careful with their forecasts. For one thing, there must be greater effort to improve the fit of models to reality by continuously updating parameters that are inputs into the models. Since exponential models are so sensitive to parameter values, extra care must be taken to ensure that those parameter estimates are continually revised. Only one of the models initially presented to the government continually updated parameter estimates—the one out of the University of Michigan (Wang et al. 2020). Bhramar Mukherjee's laboratory admirably took the baton from that group and continued providing updated parameters and forecasts throughout the pandemic. I worked with a team that included Luis Bettencourt and Satej Soman, that did the same for a few States during the pandemic. Our code is posted and can be used and modified by Indian groups who work on future pandemics.

Another precaution is that models should not be used for long-term projections. As noted, models with exponential disease growth are prone to massive errors even over a period of a few months. This is not to suggest that there may not be massive caseloads. Instead, it is a warning to account for extremely wide confidence intervals before making policy choices.

4.2. The Benefits and Costs of the Lockdown

Prime Minister Modi announced a one-day *janata* or voluntary lockdown and then, a day later, an indefinite national lockdown on 24 March 2020. That lockdown supplemented pre-existing travel restrictions and was among the harshest lockdowns declared around the world (Figure 5). As I explained above, a lockdown is a suppression policy that is both deeper (restricting more activity) than travel restrictions and broader (covering a larger geographic area) than containment zones or quarantines. In India's case, the lockdown was a stay-at-home policy combined with restrictions on non-essential businesses and supply chains. Disease and economic surveillance can be used to evaluate the efficacy and costs of the lockdown.

4.2.1. Benefits

A casual examination of case and death counts (Figure 5) yields mixed signals about the benefits of the lockdown. On the one hand, the lockdown did not prevent the rise in cases. On the other hand, cases did not rise until the lockdown was lifted. Perhaps the problem was that the lockdown was lifted too early. Alternatively, one might argue that the lockdown delayed a rise in cases and bought time for the government to bolster hospital capacity, reducing the mortality rate from infection.

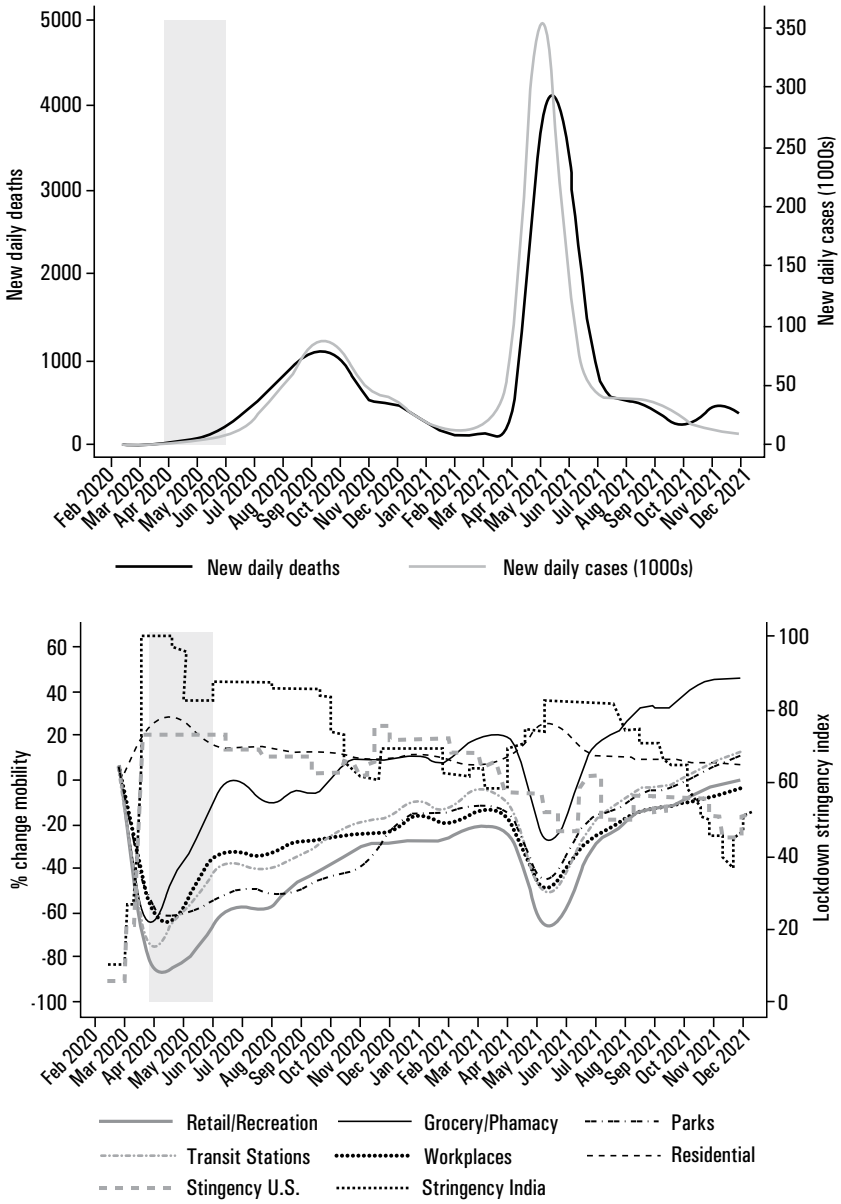
Amount of delay. There are several reasons to question the impact of the lockdown on delaying the growth of cases. First, economic theory suggests that there would have been a reduction in economic activity even in the absence of the lockdown. People would have voluntarily socially distanced to limit exposure to infection. That would also have delayed the peak in cases, to some extent, and bought time for the government to shore up testing and health care facilities.

Second, and more importantly, the benefits and costs of lockdown were distributed unevenly. A serological survey conducted in Mumbai found that roughly 55 percent of slum residents and 15 percent of non-slum residents had antibodies to COVID by July 2020, just five months into the epidemic (Malani et al. 2020b). This finding suggests that the lockdown may have slowed the pandemic outside of slums but accelerated it inside slums.

The logic emerges from two observations. First, slums are incredibly dense and non-slums are not. For example, the average distance between people in Dharavi, assuming people are evenly distributed, is less than 3 meters.[3] Actual distances are likely much smaller as walls prevent even spacing and people are

3. Dharavi has a population density of roughly 340,000 persons per square kilometer. Assuming that individual locations are uncorrelated, one can model the spatial distribution of people as a Poisson. The average distance between persons is then 1/(2 s), where 's' is the square root of population density per meter. See https://physics.stackexchange.com/questions/534272/what-is-the-relation-between-density-and-average-distance-to-nearest-neighbour.

FIGURE 5. COVID Trajectory, Severity of Lockdown, and Mobility Changes



Source and Notes: These figures and this note are copied from Figure A1 in Gupta et al. (2021b). Case and death data are from www.covid19India.org. We show aggregated daily reported cases and deaths from the government. The shaded period marks the national lockdown. Lockdown severity data are from Hale et al. (2020). Mobility data are from Google mobility reports (Google LLC 2021). The shaded period marks the national lockdown. Time periods cover February 2020–January 2021.

clustered into small homes. In contrast non-slums are nearly one-tenth as dense as slums. For example, nearly half of Mumbai's population lives in slums, but slums occupy just 12 percent of Mumbai's land. Second, on most days, a typical slum resident works as, e.g., a domestic laborer or construction worker in less dense non-slum Mumbai. So, during work hours, the density in slums falls and the density in non-slums rises.

When the lockdown was declared, it stopped work and thus increased daytime density in slums and reduced it in non-slums. It is plausible that this shutting down of work mobility accelerated the spread of infection in slums. Estimating the magnitude of this effect is difficult. We do not know the rate at which the pandemic would have spread if slums had less daytime interpersonal contact. Perhaps slums, even when residents left for work, had enough density at night for the infection to spread more rapidly in slums than non-slums. But the qualitative effect of the lockdown was to increase density and thus the disease burden in slums and lower it in non-slums.

Making use of delay. Moreover, it is unclear how much the lockdown improved pandemic preparedness. The MoHFW convened a COVID war-room that, among other things, began taking stock of and organizing bed capacity. Unfortunately, it is difficult to assess the impact because the resulting data on hospital facilities were not made public.

However, there are reasons to doubt that much could have been accomplished in the short run. First, India has very poor data on hospital capacity. Paul Novosad and Sam Asher attempted to examine data directly on bed capacity from DLHS-4 (2012–13) and the Population Census (2011), and indirectly on hospital employment from the Economic Census. (They tried but were unable to obtain Registry of Hospitals in Network of Insurance (ROHINI) data at the district level.) A surprising finding was that there was low correlation between the data sets on district-level hospital capacity, strong evidence of the poor data quality. Conducting a facilities census takes time in normal times, let alone a pandemic. Moreover, private facilities may be hesitant to report capacity to the MoHFW for fear of their facilities being seized for COVID care, crowding out private revenue from non-COVID cases.

Second, India had among the lowest rates of beds per capita prior to the pandemic (Nagarajan 2020),[4] and hospital capacity is a capital asset that is difficult to scale in the short run. In contrast to, say, China, India is not known for the ability to build infrastructure quickly. (That this limitation is common to many countries, including high-income countries, is little solace in a pandemic.) The best that could be done quickly is to revise bed allocations to (a) prioritize beds for COVID versus less urgent diagnoses, and (b) designate specialized COVID facilities to reduce the risk that hospitals spread COVID, a substantial

4. Novosad and Asher (unpublished memo on file with author) believed that even a 1 percent rate of (symptomatic) infection would overwhelm hospital capacity.

concern in prior pandemics like SARS (Bennett et al. (2015) and also with COVID (Ngandu et al. 2022). Again, due to lack of data, it is difficult to assess the progress made on these strategies during the lockdown.

4.2.2. Costs

To assess the cost of lockdown, I turn to economic surveillance. India does not have good, real-time monitoring of health care. For example, other countries have birth data, cause-specific mortality data, and insurance claims data, typically furnished by the government. These data are either not gathered or not released by governments in India.

Economic data. Better data are available for economic surveillance. Even here, though, we rely on private sector surveys as the government did not conduct surveys on household finance during the pandemic, as far as we know. One complication is that the lockdown shut down not just trade, but also in-person surveys.[5] This means that the data we employ are gathered using phone surveys, which may have different quality.

In my opinion, the best of these surveys is the Consumer Pyramids Household Survey (CPHS), conducted by the Centre for Monitoring Indian Economy. This is a household-level panel data set that includes roughly 175,000 households with nearly 1 million members. Data on each household is longitudinal, gathered every four months. Moreover, sampling is staggered so that data on a representative cross-section is available each month.

The CPHS data are not perfect: people criticize its use of random systematic sampling rather than random sampling from a census, sampling based on town-population strata rather than in proportion to specific town populations, and its possible oversampling of main streets (relative to side streets) in villages (Somanchi 2021).

However, the alternative to the CPHS is not better sampled data, but rather no data: there is no alternative available for the relevant time frame. Moreover, some of the critiques advocate sampling methods that are better for some uses, but worse for others. And by better, I mean higher power, not less bias. An implication is that CPHS has lower power than it could have for some uses. Even that weakness is overcome by its relatively large sample size. Finally, scholars are actively working on alternative weights to make CPHS comparable to pre-pandemic data sets like the NSS or Census (Sinha and van der Weide 2022).

The CPHS did not stop during lockdown. But it did switch from in-person to telephonic. Because the firm—in the interest of quality—used its managers

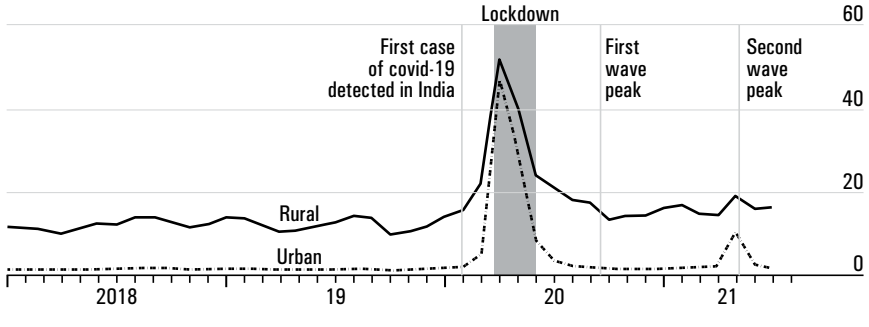
5. Lockdown also made disease surveillance difficult. Here is anecdotal evidence from serological surveillance by the State of Karnataka and advised by Manoj Mohanan, Anu Acharya, Kaushik Krishnan and I, from June to August 2020. Phlebotomists began surveillance in Bengaluru in June but had to finish early because of a lockdown declared in that city that barred them from collecting blood. We then returned later after the lockdown was lifted.

rather than door-to-door surveyors to conduct phone surveys, it could not survey all households. Managers were given a list of phone numbers in their jurisdictions but no other survey data on numbers and asked to sample roughly half the households in each jurisdiction, preserving the urban-rural balance.

While the selection was not formally random, work by Arpit Gupta, Bartek Woda and me (Gupta et al. 2021a) suggests that a LASSO-selected prediction model using the previous rounds data on households could explain at most 1 percent of the variation in selection for telephonic surveys. Non-response to telephonic surveys resulted in an overall response rate of 35 percent of the formal sample, in contrast to the usual 85 percent response rate pre-COVID. After the lockdown, sample response rates rose to about 75 percent.

Poverty and inequality. The CPHS data show that poverty and inequality spiked during the lockdown. Using the World Bank's $1.90 per day measure, the extreme poverty rate (measured by income) spiked from 2 percent to nearly 52 percent in urban areas (Figure 6). Rural areas started poorer but experienced a similar spike: from 12 percent to 47 percent. After the lockdown, poverty declined to 2 percent in urban areas, but was 14 percent in rural areas.

FIGURE 6. Share of People in Extreme Poverty (Percent)

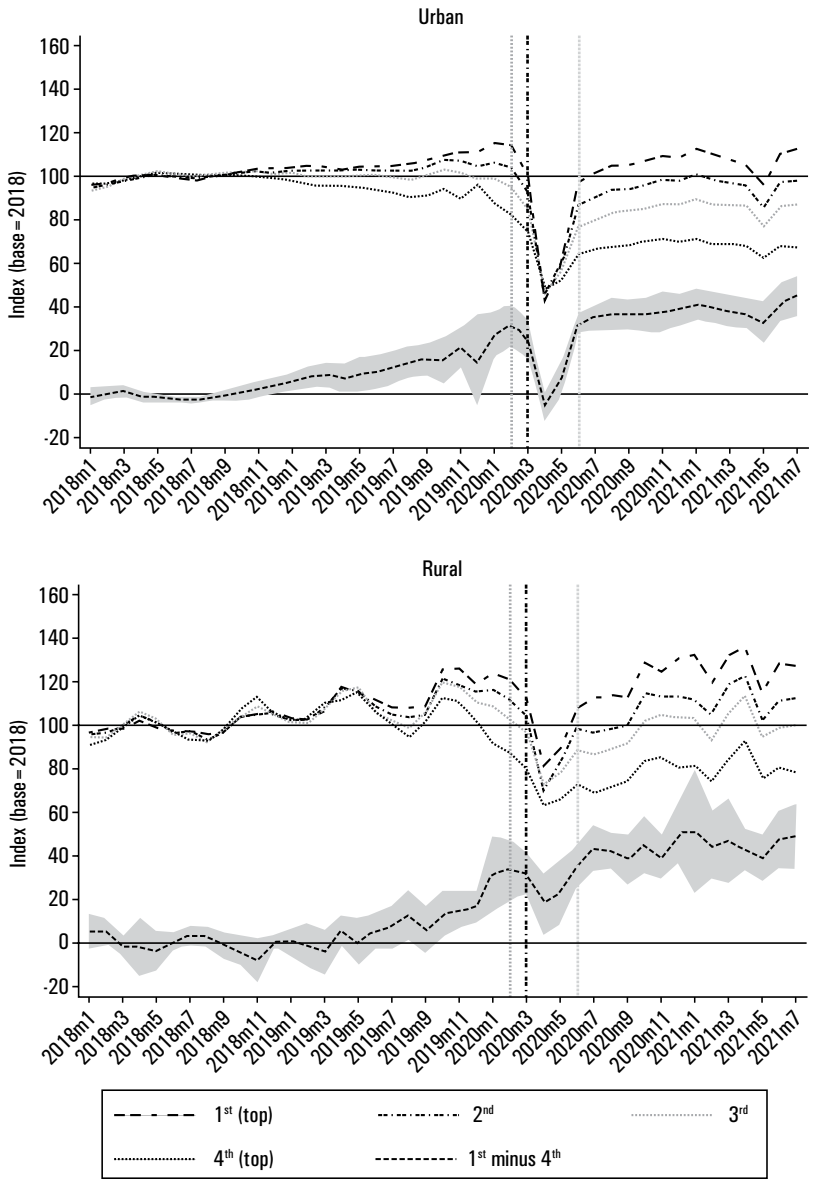


Source and Notes: Extreme poverty is defined as consumption below $1.90 on a PPP basis. Consumption data is from CPHS. PPP data is from IMF. This figure is copied from (Economist Daily Chart 2022), based on data provided by (Gupta et al. 2021b).

I measure inequality in two steps. First, I normalize individual monthly income by an individual average income in 2018 and then sort individuals into quartiles based on their 2018 income. Second, I subtract the average monthly normalized income in the top quartile of income earners from that in the bottom quartile of income. The higher is this measure of inequality, the less is the inequality. The level of this index measure percentage point changes in inequality.

Figure 7 shows that inequality had been falling since 2018. When the pandemic hit, that trend reversed a bit in urban areas. But when the lockdown

FIGURE 7. Normalized Income over Time (2018 Baseline)



Source and Notes: This figure is taken from Figure 1B in Gupta et al. (2021b). Data are from the CPHS. The figure plots the fixed effects (lines) and quartile x month fixed effects estimated by using a regression of normalized income on quartile x month fixed effects. The lines are the equivalent of the weighted average of per-capita income within income quartiles in each State x urban status location, using individual member weights from CPHS. The units are an index where 100 is average 2018 income of a person. The dashed line at the bottom indicates the difference between the first- and fourth-quartile index for income, measuring the decline in inequality in percentage points. Shaded area is the 95% confidence interval around a statistic. Dashed vertical lines in February 2020, March 2020, and June 2020 indicate the first month of the pandemic (left vertical line), the month the national lockdown started (middle vertical line), and the month the national lockdown ended (right vertical line).

was declared, all the gains since 2018 were erased. Both the effects were less pronounced in rural areas. This is a lockdown-specific effect because, once the lockdown ended, inequality returned to pre-pandemic levels. This finding is not specific to my specific measure of inequality. As Gupta et al. (2021b) show, the Gini coefficient also spiked during the lockdown.

Consumption effects were less severe. Gupta et al. (2021a) show that the median consumption did not fall as much as the median income. Households were equally able to smooth consumption after idiosyncratic income shocks remained the same before and after the pandemic, and across income classes. The Marginal propensity to consume remained roughly 10 percent. However, households faced a larger aggregate shock than consumption did respond to that. Nevertheless, consistent with Engel's law, households were able to increase the food (and fuel) share of their income to protect against hunger.

4.2.3. Lessons

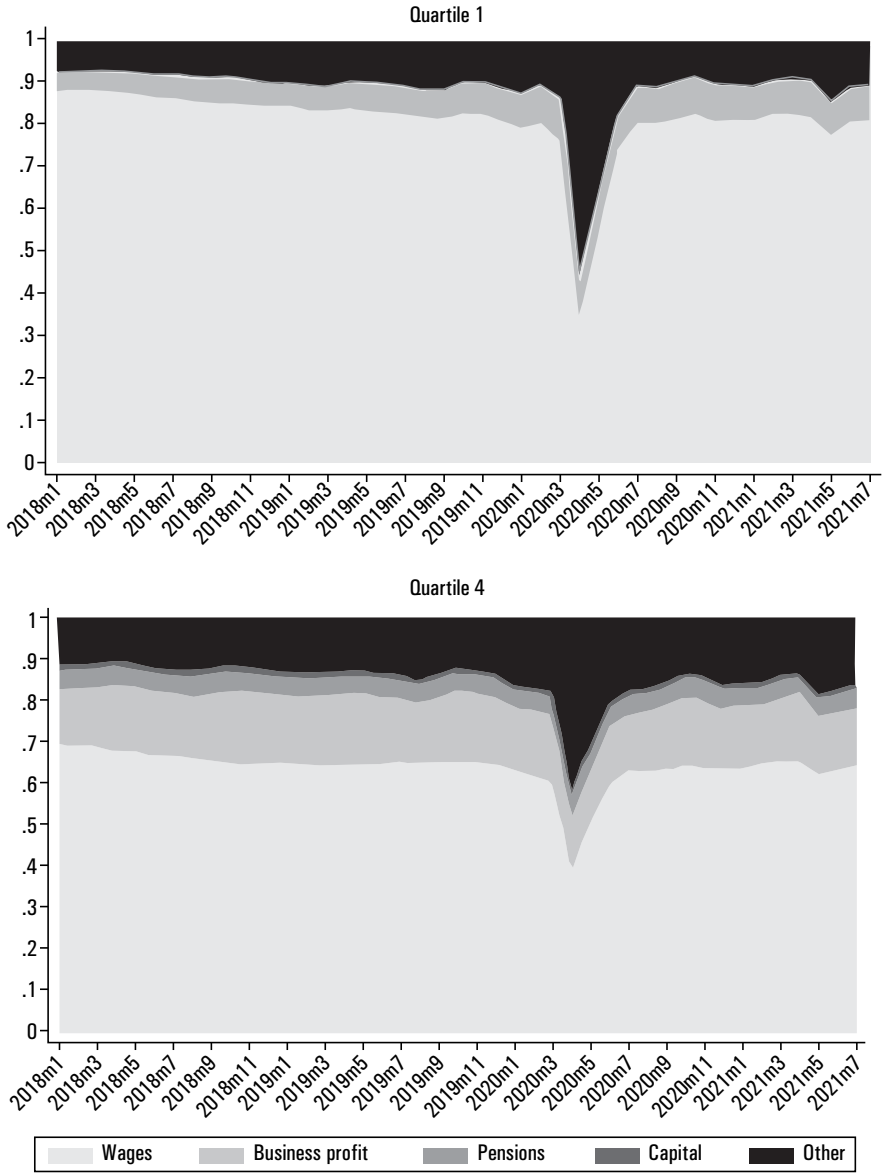
India's experience with the lockdown was not unique. Many nations imposed harsh but short-lived lockdowns at the start of the pandemic. They were lifted in part because of how disruptive they are. The V-shaped economic recovery in economies across the world are proof of this pattern.

There are several lessons in that common experience. First, once it was confirmed that the reproductive rate of the new infectious disease had a high level of dispersion, countries should have abandoned lockdowns and instead targeted suppression at highly infectious people (Lloyd-Smith et al. 2005). Narrower, targeted suppression may have achieved the same disease control with less economic impact. Moreover, there may have been greater support for keeping those restrictions in place. Financial compensation for those individuals subject to targeted suppression could have overcome political and ethical opposition to those measures.

Second, urban lockdowns seem especially inequitable. They may hasten disease spread among slum-dwellers, who live in poor communities that have above average density. Perhaps cities should abandon urban lockdowns unless an infection does not have serious health consequences, the population has developed immunity to the infection, or governments can substantially increase supply of health care to slums during a pandemic.

Third, if targeted lockdowns are not possible, lockdowns should be accompanied by social programs to ensure that spiking poverty does not lead to hunger and associated mortality. It would be a shame to replace mortality from infection with mortality from famine. Households will attempt to protect themselves. But if savings are low, then the government should step in to provide a safety net. If food supply is not constrained, cash transfers may be enough. If supply is constrained, perhaps by lockdown, focus should be on ensuring that essential services like agriculture are effectively exempted. The CPHS evidence suggests India's lockdown successfully exempted agricultural production so

FIGURE 8. Sources of Income for the Top (1) and Bottom (4) Quartile of Individuals over Time, with Government Transfers Reported in "Other"



Source and Notes: Figure and note taken from Figure 4 in Gupta et al. (2021b). Share of income is from different income sources. Capital income includes dividends, interest, rent, sale of assets outside of pension accounts. Other income includes government transfers, private transfers, value of agricultural goods produced for self-consumption, lottery winnings, insurance payouts.

that households were able to obtain food. Likewise, India increased transfers, especially to the poor, as Figure 8 indicates.

Finally, it may be that the cost of lockdowns is greater than the benefit. Voluntary social distancing may also flatten the curve of cases. Moreover, it may have less negative economic effects, especially on the poor. The difference between mandatory and voluntary distancing is that individuals choose the amount of risk they abjure based on personal circumstances. This frees the poor to continue working if their economic losses outweigh the health gains from distancing. Some may object that this imposes health costs on the poor, but that view fails to account for the fact that the poor may care about both health and non-health consumption.

Three pieces of evidence support the tradeoff implied by voluntary distancing. First, voluntary distancing had fewer negative impacts on economic welfare. Mobility remained suppressed even after the national lockdown (Figure 5), but poverty fell to nearly pre-pandemic levels and inequality resumed its pre-pandemic downward trend (Figure 6).

Second, cases did not rise immediately after the lockdown was lifted. The peak of the first wave occurred in September, more than three months after the lockdown ended (Figure 5). One cannot disentangle the effect of mandatory versus voluntary lockdown on the delay. But the data on symptomatic cases is also consistent with voluntary distancing keeping the peak at bay.

5. Later Stage Surveillance

5.1. Serological Testing

After India's lockdown, the focus of surveillance shifted from purely antigenic surveillance to also conducting serological surveillance for anti-COVID antibodies. Serological surveillance involves gathering blood and testing it for antibodies to SARS-CoV-2.

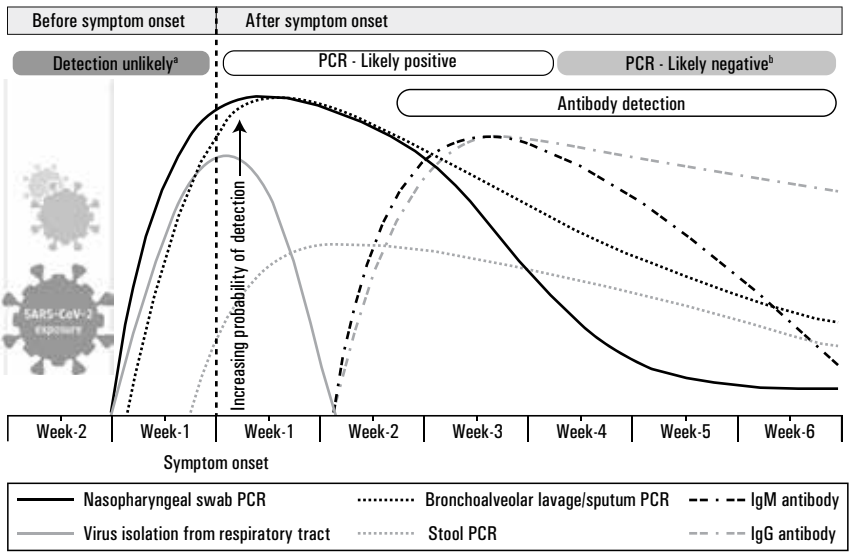
This qualitative expansion of surveillance happened for two reasons. First, the government restricted viral testing on symptomatic cases but did not restrict serological surveillance, in part because it did not have diagnostic value. The presence of antibodies indicates prior and likely cleared infection. Neither quarantine, ventilation nor antivirals are helpful. This difference in restrictions on testing is evidence of the impact of having medical doctors rather than public health officials in charge of surveillance: antigenic surveillance was restricted based on diagnostic value, while serological testing was not.

Second, antigenic testing, especially if limited in quantity or if asymptomatic cases are not tested, cannot inform population immunity and thus future risk. Antigenic testing signals current infection, especially at low cycles or equivalently high concentrations. One cannot simply count up prior cases to

get the stock of people with immunity if not everyone can get tested or testing is restricted to symptomatic cases. (Though the restriction may be a product of limited supply.)

The main advantage of serological surveillance is that it can measure, at least for several months, recovery from infection. In contrast, antigenic testing with, for example, RTPCR can only detect cleared infection for 2-3 weeks after infection (Figure 9). Since population-level susceptibility to infection is declining as a function of the share that are recovered, serological testing provides better measures of forward-looking risk to public health. The latter is critical for planning suppression policy and vaccination campaigns.

FIGURE 9. Diagnostic Detection of SARS-CoV-2 and Associated Antibodies over Time



Source and Notes: This figure is copied from Sethuraman et al. (2020), While this figure focuses on individuals with symptoms, individuals without symptoms have a similar time profile, though the PCR negative period may be shorter and the level of antibodies may be lower.

5.1.1. Nature of Serological Tests

Serological tests vary along two dimensions. One is whether the test is a rapid test or a laboratory test. A rapid test can be implemented with minimal blood (dried blood spots) and gives answers quickly in the field. However, there are drawbacks. The sensitivity (probability a truly positive case yields a positive test result) and specificity (the probability a truly negative case yields a negative test

result) of tests is lower.[6] Some of the time gain from rapid results (as opposed to venous blood draws) is lost by having to wait for test results in the field to record them. Moreover, it is difficult to ensure that surveyors wait long enough to correctly interpret test results when recording them.

A laboratory test has a higher accuracy. However, it requires a venous blood draw. Although one might suspect a high non-consent rate, we found reasonable consent rate in our work in Mumbai and Karnataka. This could be a product of heightened concerns about the pandemic at its start. Another drawback is the need to maintain a cold chain: the blood must be kept refrigerated from the field to the laboratory. This is an especially challenging problem in rural areas.

A second dimension along which serological tests, in particular laboratory tests,[7] vary is the method of lab test conducted. There are usually three options available. The gold standard test looks for neutralizing antibodies, i.e., antibodies that prevent the virus from entering a human cell. These are antibodies that attach to proteins on the face of a virus that the virus uses to cleave a cell. (The alternative is antibodies that attach to the virus, do not prevent it from entering a human cell, but do serve as a beacon for other immune system agents, such as white blood cells, to find and attack viral particles.) Neutralizing antibody tests are desirable because scientists know for sure that these antibodies are protective for humans. Other antibodies may or may not be good beacons depending on how well they attach to SARS-CoV-2 or how effective other immune system agents are at locating the beacon or killing any virus they find.

The second-best test is an enzyme-linked immunoassay or ELISA test. These have relatively high sensitivity, but for all SARS-CoV-2-related antibodies. As such they may not be as reliable a measure of immune function against COVID. A compensating differential is that these tests are less expensive and take less time than neutralizing antibody tests. That said, these tests do not have a natural unit, e.g., antibody concentration, unless they are done at different dilutions, which add to the time and expense required for these tests.

The third-best tests are chemiluminescent immunoassay or CLIA tests.[8] A laboratory can complete these tests more quickly than ELISA tests.

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6. Moreover, accuracy might vary across lots of the same test. We abandoned the regulatorily approved rapid tests in our work in Karnataka because when we tried to validate the rapid tests we obtained, we found they were less accurate than reported accuracy rates from the manufacturer. This is not a problem with laboratory tests as laboratories usually create controls for each batch of reagent by, for example, including a placebo in one row of wells per coated plate.

7. Rapid tests are usually chemiluminescent immunoassay or CLIA tests. After adding a sample, a colored line appears if the test is positive, i.e., a chemical reaction creates luminescence or distinct (reflection of) light waves. However, there are also now FDA-approved rapid tests for neutralizing antibodies. We employed these in a study in the slums and non-slums of Bengaluru for a project whose data is currently being analyzed.

8. Both ELISA and CLIE tests require specific machines, an important fixed cost. Their availability at local labs affects transport costs for samples.

They may have lower sensitivity than ELISA tests but have reasonable specificity.[9]

5.1.2. Obstacles to Obtaining Serological Tests

Despite the relevance of serological testing for pandemic policy, there were two policy obstacles to such surveillance, especially with rapid antibody tests.

First, rather than the Central Drugs Standard Control Organisation (CDSCO), ICMR took control of diagnostic test approval. Initially ICMR was skeptical of rapid antibody tests because of poor sensitivity and specificity. That objection makes sense for diagnostic tests used primarily for managing patient treatment. However, it does not make sense for tests used for population-level surveillance and policy. One can use statistical methods, like the Rogan-Gladden formula (Rogan and Gladen 1978), to obtain unbiased[10] estimates of population-level prevalence even with individually inaccurate tests.

As a result of this regulatory uncertainty, our surveillance efforts turned to more cumbersome lab tests. Even there we found that it was difficult to find private labs that had approval to conduct COVID tests. Certain COVID testing required heightened safety protocols. While several labs had submitted applications for licensing their safety, regulatory authorities were unable to act on those in an expeditious manner that reflected the urgency of the pandemic.

Second, the Central Board of Indirect Taxes and Customs (CBIC or the Board), functioning under the Department of Revenue in the Ministry of Finance, continued to impose tariffs on testing products even as the epidemic was growing and there were either no domestically produced tests or a shortage of such tests. A rumor we heard when trying to import tests early in the pandemic is that authorities were hoping tariffs would promote domestic production of tests. A pandemic that risked tens or hundreds of thousands of Indian lives is perhaps too high a price to pay for import substitution. Ultimately, though with some delay, foreign companies set up domestic partnership to produce their rapid tests locally and some domestic firms began producing their own rapid tests.

5.1.3. Implementation of Surveillance

Once serological tests were obtained, a statistical challenge emerged: how to obtain representative samples on which to conduct tests. For testing to give

9. The initial results from the serological study in Mumbai employed CLIA tests because of speed; these tests were later validated with ELISA tests, though those results have not been reported. Our sero-survey in Karnataka employed ELISA tests because we had more time to complete the laboratory work. Finally, an ongoing analysis of samples from slum and non-slums of Bengaluru employed both ELISA and rapid neutralizing antibody assays to provide multiple benchmarks for the main goal of that study, which is to measure cellular immunity.

10. A minimum level of accuracy (e.g., a positive case more likely than not to show a positive result) is required for these to assess the variance of estimates of seroprevalence.

us reliable estimates of population-level immunity, the samples need to be representative of the population.

Early on we tried to obtain representative samples by obtaining a census of all people and selecting a random sample from that census. It is too hard to conduct a census during a pandemic, so we turned to a pre-existing public census: voting rolls. Our strategy was to randomly select voting booth rolls and then randomly select individuals from those rolls. This effort proved difficult as the data were in poor shape. Many rolls were not in electronic form or not in English. Individual names and addresses were not always accurate. And the young were excluded from those rolls.

A second, more promising approach was systematic random sampling from random starting points. In the Mumbai serological survey, the team conducted systematic sampling from random starting points in slums and non-slums (Malaniet al. 2020b). In the four rounds of the Tamil Nadu serological survey, the State conducted systematic random sampling from randomly selected villages and towns in each district (Selvavinayagam et al. 2021).

There are two logistical problems with systematic random sampling. One is that, because sampling does not start with a census, the survey must collect data on family composition to generate weights that ensure that the weighted demographic composition of sample matches that of the population. The other is that random starting points must be selected from physical areas that are populated with humans. This requires a map with the universe of settlements. Such maps do not always track slums and nomadic tribals well.

A third approach is to use a pre-existing representative sample, usually a government sample based on a random draw from a census or a private sample that used a pre-pandemic systematic sampling exercise. In the Karnataka serological survey, the team used a representative sample from an existing survey frame (CPHS), which in turn, used systematic sampling (Mohanan et al. 2021). (The team approached other organizations for the right to use their sample but were unsuccessful.)

5.1.4. Lessons from Serological Surveillance

I was involved in four major serological surveys: the study of Mumbai slums and non-slums (Malani et al. 2020b), the study of urban and rural Karnataka (Mohanan et al. 2021), a follow-up study in the slums and non-slums of Bengaluru (where data analysis is ongoing), and four rounds of district-wise surveys in Tamil Nadu (Selvavinayagam et al. 2021).[11] The total sample size across these surveys was roughly 110,000 persons, representative of a population of nearly 170 million persons.[12]

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11. In addition, I have provided advice to several other States that conducted and analyzed their own sero-surveys.

12. The total is 380 million if one counts populations surveyed multiple times.

These surveys yielded four important lessons. First, serological surveys are relatively inexpensive and quick. The Mumbai and Karnataka surveys each cost roughly INR one crore (ignoring the cost of the leadership team). The Mumbai survey took about two weeks to complete surveillance and two weeks to conduct data work. The Karnataka study took two-and-a-half months, but that is because we had a smaller team that visiting districts serially. In contrast, Tamil Nadu completed some rounds of its survey in two weeks because it employed government infrastructure and workers, and operated in 38 districts in parallel.

Second, the pandemic spread quickly and to a greater level than expected given the lockdown and antigenic testing results. The Mumbai serological study suggested that over half of slums were infected by July. This result was validated by surveys in other slums, even in other countries such as Bangladesh. Our Karnataka sero-survey suggested that 46 percent of Karnataka had COVID antibodies by August. All this was despite the lockdown and before the first wave peaked according to antigenic testing.

A corollary is that the government's initial pronouncements about the lack of community spread were incorrect. Either the government's testing strategy did not allow it to see that or its efforts to stem panic ended up reducing the credibility of government messaging.

Third, the only regular predictor of infection rates is population density. The Mumbai, Karnataka, and Tamil Nadu surveys did not reveal consistent differences in rates of infection by age or sex. However, they did reveal that slums had more infections than non-slums and that urban areas had more infections than rural areas. (Those gaps shrunk over time, as several waves of infection eventually did hit even less dense areas.)

Fourth, serological surveys measure past infection only before vaccination campaigns. Both prior infection and vaccination generate antibodies detected by serological tests. If the purpose of such testing is to measure the rate at which infection spreads prior to vaccination, to assess the risk from existing infrastructure and population mixing patterns, then vaccination confounds estimates of that risk. For example, between the third (June 2021) and fourth (December 2021) rounds of the Tamil Nadu survey, seropositivity increased by 23 percent, but 65 percent of the increase was due to the State's vaccination campaign rather than new infections. In contrast, 100 percent of round 1 (November 2020) and nearly all of round 2 (April 2021) seropositivity were attributable to infections (Selvavinayagam et al. 2021).

Fifth, antibodies are a medium-run measure of immunity. The metabolic (caloric) cost of mounting an immune response, including antibody production, is large (Demas et al. 1997). The body stops producing and slowly begins clearing antibodies after an infection is cleared. As a result, antibodies decline. Nevertheless, the body retains cellular memory (via T and B cells) of an infection that enables it to spin up antibodies more quickly the next time it is infected,

reducing the burden from that infection.[13] Thus, in the absence of repeated reinfection or boosters, serological studies may underestimate population-level immunity. For example, between round 1 (November 2020) and round 2 (April 2021) of the Tamil Nadu surveys, seroprevalence fell from 31.5 percent to 22.9 percent. Certainly, neither the amount of prior infection nor cellular immunity declined in that short period.

5.1.5. Reforms

Experience with serological testing suggests several reforms to prepare for the next pandemic.

First, the government should embrace serological testing earlier in a pandemic. It should not make assumptions about whether a disease is symptomatic or not and let testing decide that. Moreover, it should appreciate that serological testing can inform population immunity better than antigenic testing, especially if the latter is limited and not conducted repeatedly on representative populations.

Second, the government should eliminate barriers to both antigenic and serological tests, especially when those are employed for population-level surveillance as opposed to individual-level diagnostics for purposes of quarantine and treatment. This means that whatever agency regulates testing should accept tests approved by foreign regulators that are reliable, such as the US Food and Drug Administration or the European Medicines Agency. Moreover, the government should automatically suspend tariffs on tests and testing materials once a pandemic is declared and there are inadequate domestic producers of tests. Finally, the drug regulator should also encourage private labs to apply for the BSL certification required to test for pandemic diseases, and expeditiously process those applications before the next pandemic. The regulator should not impose unnecessary safety requirements, but rigorously enforce those that are required to avoid infection of lab personnel and shutdown of labs.

Before implementing these reforms, the government should carefully consider which agency should regulate testing and which should conduct central government surveillance and research. It may be too much to ask one agency to do all these tasks. Moreover, government researchers may overweight their own research, generating conflicts of interest that make impartial regulation of other people's research more difficult.

Third, the government should expedite the implementation of population-level surveillance. It should prepare representative samples for testing. The Census Division of the Home Ministry and the National Statistical Office are

13. In theory, having a high antibody count when re-infected will reduce the health consequences of that re-infection more than merely having cellular memory because cellular immunity has a recall period that slows antibody response. The magnitude of this recall period, which is still being investigated, appears to fall with vaccine boosters (Wragg et al. 2022).

in a good position to do this because they conduct several surveys that entail generating censuses. The government may also want to maintain a stockpile of consumables such as plates and reagents, though the price of stockpiling rises if these are not durable inputs.

5.2. Measuring Mortality

Background. A central question in the pandemic is the probability of death, given infection (i.e., Infection Fatality Rate or IFR) and the total mortality burden.

While the infection has a substantial morbidity burden, that is difficult to measure. It is well accepted that COVID has a short-lived morbidity burden on those with symptomatic infection. Long COVID, which may last for months, if not years, is still being investigated.

Information on mortality is important for two reasons. First, to the extent that cases are not well counted, perhaps because of a shortage of supply or demand for tests, deaths are an indirect measure of both flow and stock of infection. Second, the ratio of death to cases provides a measure of the impact of infection. The greater the IFR, the more important it is to avoid infection.

Initially, the infection fatality rate was measured by dividing the number officially reported deaths by officially reported cases. The problem is that this might overestimate death rates. The government was only testing mainly symptomatic cases, and only a fraction of even those. This undercount would deflate the denominator of IFR.[14]

A solution was to replace the denominator with seroprevalence times population. This would capture all cases in the denominator. But this correct led to extremely low estimates of infection fatality rates, with India having perhaps one-tenth the estimated IFR of the US. Although some people proposed theories for why India might face a lower mortality burden,[15] others quite reasonably questioned India's estimate of COVID deaths (Cai et al. 2021; Levin et al. 2022). The same shortage of tests that plagued case counts might also affect death counts. Indeed, the value of testing a dead person not tested for COVID when alive has zero diagnostic value, which drove testing priorities. Finally, there may have been political pressure not to test dead bodies for COVID to avoid either panic or criticism of government COVID policy.

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14. Another, more technical problem is that the numerator and denominator can be measured as stocks or flows. Taking the stock of deaths and dividing by the stock of cases is fine if the IFR remains constant over time. But improved medical care might cause the ratio of stock values to overestimate the IFR. The alternative, taking the ratio of flows, say over a week or month, can yield errors unless one knows the right lag between detection of cases and detection of deaths.

15. Several theories were proposed, including cross-protection from prior BCG vaccination, to beneficial genetic mutations, to survivorship bias. This last explanation was that India had fewer individuals who would be most vulnerable to COVID, e.g., the elderly and those with co-morbidities, because many had already died from age and co-morbidities before the pandemic.

The next correction was to replace official counts of death with estimates of excess all-cause mortality. Data on all-cause deaths were obtained from States that had disclosed deaths reported to their Civil Registration System or deaths incidentally reported among the representative sample of another survey, such as the CPHS (Malani and Ramachandran 2021; Anand et al. 2021; Jha et al. 2022). Data journalists such as Rukmini S. should also be credited for this important work (Rukmini 2021). These all-cause death numbers suggested roughly 5 million or more deaths from COVID through 2021, roughly five times the officially reported estimates of COVID deaths. These excess death estimates, consistent with Chinmay Tumbe's warning about past pandemics, suggested that India had the world's greatest burden from death. (To be fair, Levin et al. (2021) suggest that all developing countries suffered mortality rates double that of developed countries, not just India.)

But all-cause deaths have three weaknesses. First, they are highly sensitive to how one computes counterfactual all-cause mortality rates in the absence of the pandemic (Malani and Ramachandran 2021). Second, excess deaths might include both deaths directly caused by COVID and those indirectly caused by the pandemic. For example, the pandemic or the policy response to it may have caused people to drive less and have fewer accidents or to avoid non-COVID care, raising mortality. Third and relatedly, it is difficult to convert all-cause mortality into an IFR number because it may include indirect causes of death. IFR numbers are based only on deaths among individuals infected with COVID and caused by that COVID infection.

One solution to this problem is to attempt to identify COVID-specific deaths without relying on official numbers. For example, Jha et al. (2022) conducted a survey that asked households to self-report COVID and non-COVID cases, as medically certified COVID deaths are rare. While the results of this study accord with those from excess death studies, one concern is that COVID deaths were self-reported. To improve these estimates. Jha and I teamed up with CMIE to conduct verbal autopsies on deaths reported in the CPHS since 2018. Verbal autopsies use a WHO-validated interview of next of kin that is then mapped onto ICD10 diagnostic codes by specially trained doctors. Our analysis will be out soon.

Reforms. India's whiplashed experience with measuring mortality highlights the need for better mortality tracking infrastructure. First, India should make public data in death registries from all States regularly and with less delay. India provides a national estimate of deaths using the Sample Registration System, which measures births and deaths in a representative sample of roughly 830,000 persons. However, that is usually reported after a two-year delay, much too late to be useful for policymaking. India should also encourage private efforts, such as by CMIE, to measure death rates, especially if private organizations can produce data more quickly than the government.

Second, India should consider conducting autopsies on a random sub-sample of registered deaths or conducting regular verbal autopsies on a sub-sample of reported deaths. While this is not a census of deaths, its smaller sample size might make measuring the cause of deaths and quicker reporting feasible.

5.3. Economic Recovery

Background. Data from the CPHS suggests that the economic cost of the pandemic was far less severe than that of the lockdown. As we noted earlier, poverty was somewhat elevated in rural areas, but inequality declined, relative to pre-pandemic levels. The data allow us to both see how households were able to protect themselves and why inequality declined.

In the immediate aftermath of the lockdown, households took two steps to protect themselves from the shock of the lockdown. First, they tried to recover income by shifting to a different occupation, usually agriculture (Gupta et al. 2021a). This was not their only response: reservation wages fell, suggesting that workers increased supply. The problem was that, outside of agriculture, demand fell so much that the equilibrium quantity of employment fell outside agriculture.

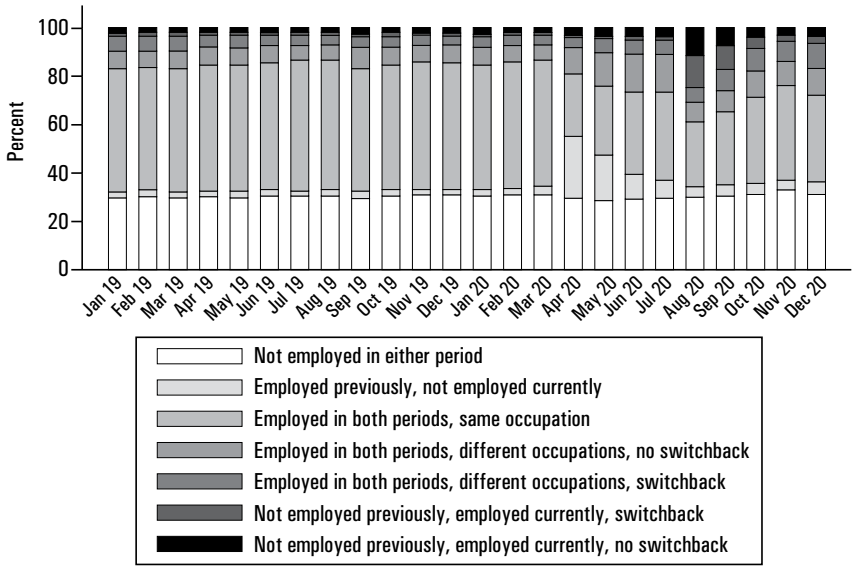
In the short run, this occupational churn was protective of income. Agriculture was the safety net for the COVID-induced post-lockdown shock to manufacturing and services. However, from the perspective of agriculture, it meant that a relative shock to another sector was transmitted to this sector. This ripple effect through labor markets means it is hard to confine shocks to a sector.

The long-run impacts of occupation churn are similarly uncertain. The shift to agriculture was temporary for about half of the shifting workers (Figure 10). Half switched back to their original sectors by the end of 2020. For those who remained in agriculture, the switch could be viewed as a long-term improvement. Frictions and risk discourage people from trying other occupations to which they might be better matched. COVID may have provided a shock that facilitated experimentation. Those that remained might be better off in their new sector. That said, the larger labor supply in agriculture might suppress wages in that sector. Moreover, development is usually associated with a shrinking agricultural sector, not a growing one.

The second step that households took to protect themselves was to use formal and informal credit and informal insurance to smooth consumption, as they did before the pandemic, and to prioritize food and fuel consumption. Households used these adaptations less than during the lockdown, but they persisted through September 2020.

An interesting feature of India's economic performance post-lockdown is that economic costs did not spike as cases did. In fact, income and consumption rose even as cases rose and peaked during India's first wave in September to

FIGURE 10. Labor Force Status over Time



Source and Notes: This figure and note are taken from Figure 8 of (Gupta et al. 2021a). This figure was constructed by, first, categorizing each member of each household into five States in each month they are observed: not employed now and in the last period, not employed now but employed last period, employed in same occupational category as the last period, employed in a different occupational category in the last period, employed but unemployed or OLF in the last period. (We define not employed as out of the labor force (OLF) or unemployed, categories found in the CPHS data set. The last period is defined as 4 months ago, which is the last time the member was surveyed in the CPHS.) We then calculate the fraction of the observed members in each State in each month. The figure includes only those members aged 18-65 years. Switchbacks are measured by examining whether the individuals switch to a sector they had previously worked in either four months or one year previously.

October 2020. This contrasts with the second wave in May 2021, during which income and consumption fell at the same time as cases and deaths peaked.

An explanation for the different economic effects of the first and second wave is the differential timing of policy response (Figure 5). In 2020, the lockdown was implemented, and mobility declined, well before the first wave. This declining mobility is a correlate of income and consumption. In 2021, however, the government did not implement local lockdowns until the second wave had arrived, that is, when mobility fell, along with income and consumption. (An argument could even be made that voluntary distancing, also reflected in mobility, declined before the government tightened suppression policy.) It is possible that wave 2 offers a counterfactual of what might have happened in 2020 if the government had not declared a lockdown in anticipation of cases.

Examining the mechanisms for why poverty returned almost to pre-pandemic levels and inequality actually fell relative to pre-pandemic levels reveals some important economic dynamics of a pandemic. Gupta et al. (2021b) suggest two

explanations for why poverty and inequality declined during the bulk of the pandemic.

First, incomes of the top quartile households (the "rich") depend more on business income (Figure 8) and business income is more sensitive to aggregate shocks. This is consistent with data from the US, which also finds that the incomes of the rich have greater "beta" (Guvenen et al. 2017). Second, the demand for services, which involved interpersonal contact and infection, fell more than the demand for manufacturing and agriculture, and the rich are more dependent on labor income from services than are the poor (Figure 11).

Almost as important as the mechanisms by which the pandemic affected poverty and inequality are the mechanisms by which it did not do so. Gupta et al. (2021b) suggest that government transfers, cash or in-kind, did rise during the pandemic, but played a small part in income dynamics (Table 2). Moreover, labor supply did not contract, despite the risk that working could lead to infection.

TABLE 2. Attribution of Changes in Inequality during the Pandemic to Different Components of Household Income

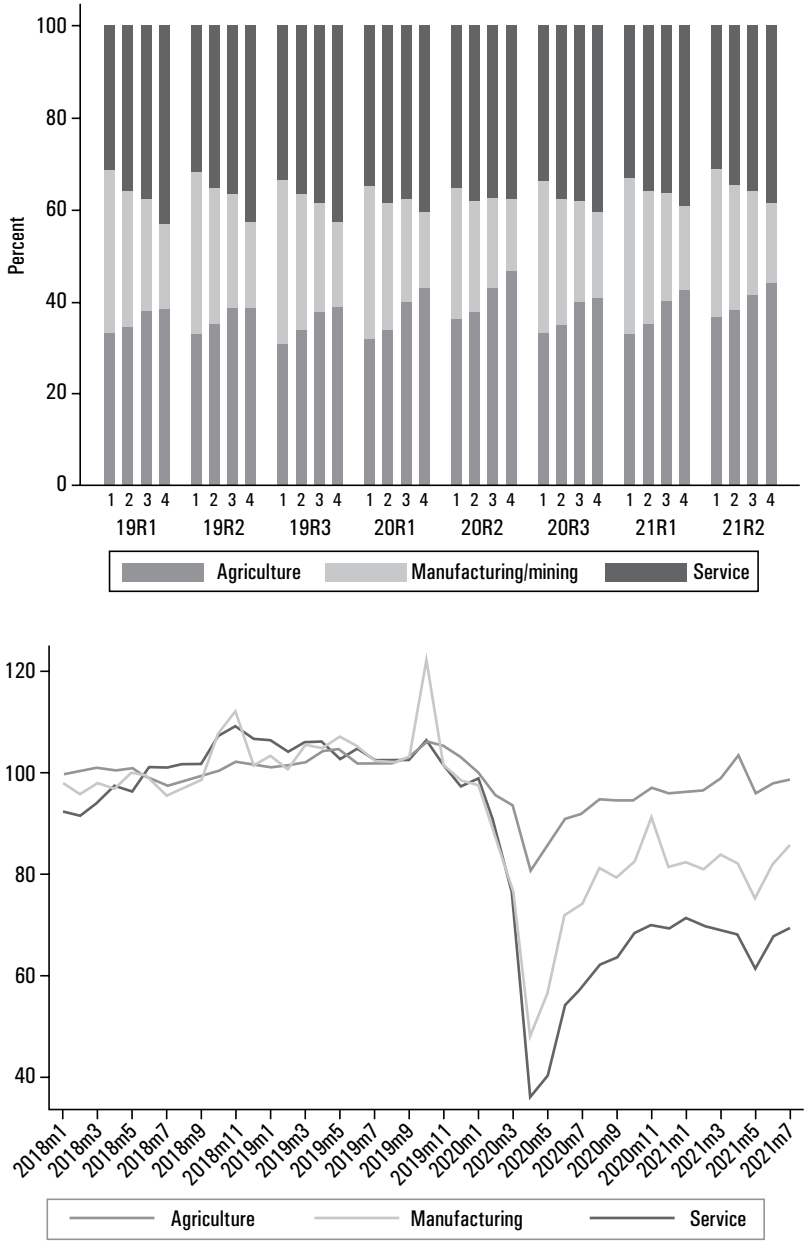
Components of income	*Change in inequality due to*	
	Change in share of income from component	*Change in amount of income from component*
Total income		-39.74
Labor income	5.41	-24.93
Transfer income	0.18	-0.33
Other income	-2.03	-1.97
Business income	-6.70	-9.38

Source and Note: Table and note is copied from Malani et al. (2022). Changes are from 2019 average to July 2021. Units are percentage points. Data is from the Consumer Pyramids Household Survey.

Reforms. Economic surveillance after the lockdown suggests economic reforms to prepare for the next pandemic. First, the government should consider conducting a CPHS-like survey that follows families over time. It can either borrow CPHS's strategy of a fixed but growing sample or mimic the Current Population Survey in the US, which rotates new households in every year, with households remaining in the sample for a fixed number of periods. It would be good to have a second data set to validate the lessons of the CPHS, especially given concerns about CPHS sampling strategy.

Second, until the Indian government has substantially greater fiscal and administrative capacity, it is unlikely that government transfers can or will play as big a role as self-protection to help the poor. This is not necessarily a bad thing: the US expanded money supply to stimulate the economy with transfers and, while successful at alleviating poverty, it may be partly responsible for the

FIGURE 11. Income by Sector and Quartile and Consumption by Sector, Over Time



Source and Notes: Figure and note copied from Figure 5 in (Gupta et al. 2021b). Left panel: Each bar reports the share of the population in each quartile with occupations in each of the three sectors (agriculture, manufacturing, and services) in each month. Right panel: This plot shows aggregate consumption of goods in three sectors by month relative to aggregate consumption in that sector in 2018.

current spike in inflation. India had a far smaller stimulus, and the poor still survived the pandemic.

Third, labor churn is an important safety valve and the government should eliminate barriers to migration and occupational change. In this crisis, the risk was from infectious disease. If in a future crisis, risk came from husbandry or blight, non-agricultural sectors may serve the cushioning role that agriculture played during COVID. To maximize the ability to adapt, the government should limit occupational licensing and regulatory hurdles to new business formation. (These reforms had value before as methods to reduce informality in the economy. Now they also serve a role in facilitation adaptation to shocks.)

6. Conclusion

Learning the lessons in this paper would not be possible without a robust private sector, collaboration between the government and the private sector, and room for respectful disagreement and debate across sectors and disciplines. In the US, there was a glut of infectious disease experts, and they used their credentials to limit out-of-the-box thinking. Moreover, political polarization meant that dissent was disparaged as politics. India to some extent avoided these pitfalls. As it builds out capacity to fight the next epidemic, it should be careful to avoid excessive specialization and injecting politics into reasonable policy dialogues.

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Comments and Discussion*

Chair: **Surjit Bhalla**
IMF and NCAER

Shamika Ravi
ORF and Brookings Institution

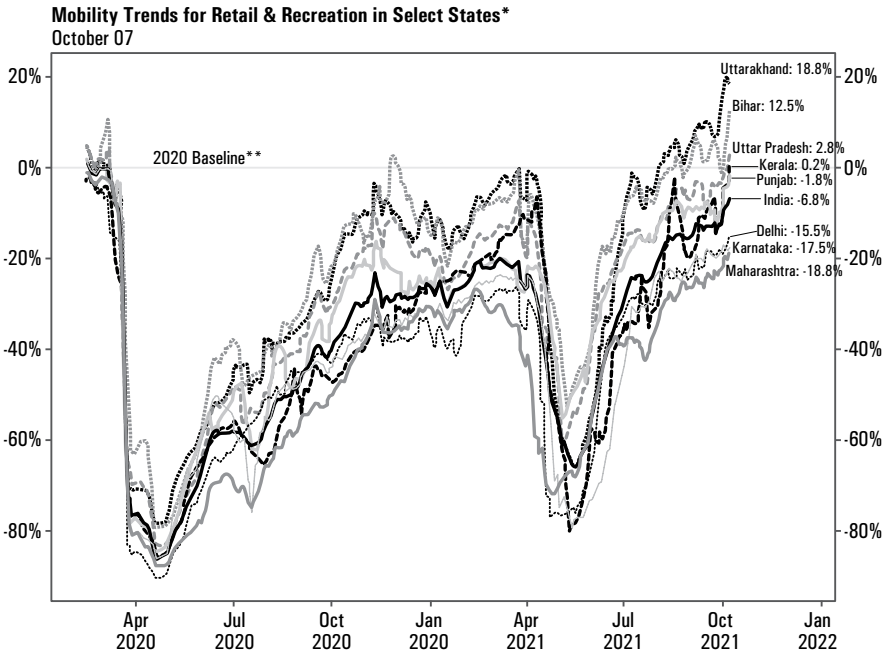
The author has written a comprehensive and exhaustive paper. He has conducted an extensive literature review but there are certain assertions which need to be addressed, and in hindsight highlight the difficulty in modeling and forecasting tail events. First is the question of how India could have detected the pandemic earlier, which is how the paper begins. The paper's assertion that India did not act until cases reached its shores needs to be questioned, in that at what level of cases did comparable countries react, in an attempt to understand what more could be done.

Next, I will be getting into specific policy initiatives such as travel restrictions and lockdowns. The paper claims that travel restrictions are of limited value in controlling epidemics and that quarantine deters testing. However, no specific evidence is provided for the same. There is also the question of how many reported cases should there be before countries announce lockdowns, and whether there was something such as optimal testing. The paper also claims that Consumer Pyramid Household Survey (CPHS) data shows that the mean and median incomes fell before the national lockdown. However, a series of steps were taken before the national lockdown. The lockdown was imposed several weeks after the Epidemics and Disease Act (EDA) was invoked across States, as well as after a series of travel restrictions were imposed. The author claims that the lockdown did not avoid infections, and in fact, it may have accelerated infections in cities. However, more research is needed on whether it was the lockdown itself that was accelerating infections or the density of the disease.

The modeling section is a good contribution to the paper. However, it exposes a gap related to human behavior, that is, the assumption that human behavior is unaffected by the occurrence of an epidemic. That this is a problematic assumption becomes clear from the Google mobility data shown in Figure 1. In

* To preserve the sense of the discussions at the India Policy Forum, these discussants' comments reflect the views expressed at the IPF and do not necessarily take into account revisions to the conference version of the paper in response to these and other comments in preparing the final, revised version published in this volume. The original conference version of the paper is available on NCAER's website at the links provided at the end of this section.

Figure 1. Google Mobility Data for States of India



*7 day rolling average
**The baseline is the median value, for the corresponding day of the week during the 5-week preriod Jan 3-Feb 6, 2020.
Places like restaurants, cafes, shopping centres, theme parks, museums, libraries, and movie theaters.
Data source: Google LLC, Google COVID-19 Community Mobility Reports
https://www.google.com/covid19/mobility/ Accessed: <2021-10-12>
Mudit Kapoor (ISI, Delhi) & Shamika Ravi (Brookings Institution)

the second wave of infections in India (the Delta wave), most States witnessed a dramatic decline in the mobility of people even without any lockdown impositions. In places where lockdowns were imposed, these were announced weeks after a significant decline in the movement of people. This shows that people's behaviors do, in fact, change according to the spread of the infection. For epidemiological models to assume otherwise is a major shortcoming of these models and the likely explanation for why the predictions were repeatedly wrong.[1]

1. "India's COVID-19 'human barricade' to keep cases under control" say experts – Reuters, 17 February 2021 (just weeks before the deadly second wave in India): https://www.reuters.com/article/health-coronavirus-india-idUSKBN2AH1K7

Trying to model tail events is not an easy feat, as depicted in various forecasts and predictions that were put forward and made publicly available to people. When modeling future events, the weights are very low, so using past data to predict the future is hugely problematic. Models may be over fitting data, which makes predictions problematic, especially considering the sparse availability of data. Unlike the predictions of epidemiological models, which were repeatedly proven wrong, we were closely scrutinizing the actual data on the ground. A simple moving average (7 days, 10 days) of actives cases, confirmed cases at the disaggregated level (States, districts) gave us much better information of the situation,[2] and was instrumental in shaping policy responses.

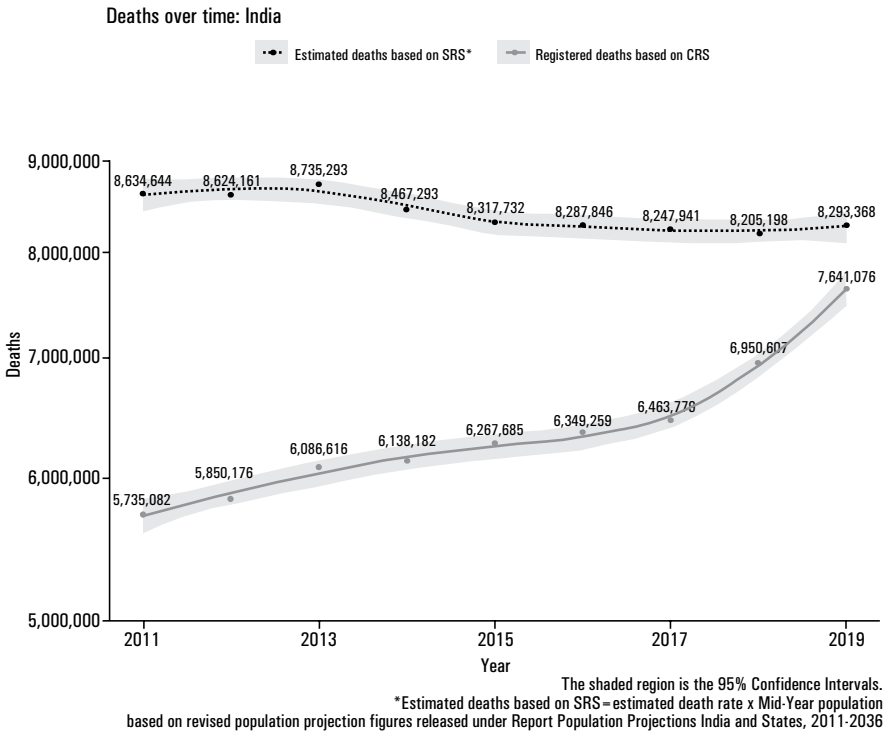
The part about estimation of excess deaths is slightly messy, as the structuring of data in India is such that makes estimating such a variable very difficult. Local area estimation makes proportionality assumptions in States where data is not available and that is a problem. Migration creates further problems as the proportionality that is being assumed does not remain stable over time. There are other concerns as well. For the WHO study, modelers have admitted errors; for example, in Germany, their model was sensitive to the spline function being used to make counter factual calculations. However, Germany is an OECD country with a robust CRV system, unlike India which makes a lot of guesstimates. The standard errors for India estimates were revised at least three times. Hence, models need to be scrutinized for their assumptions. The number of registered deaths in India has been on a rise, but the number of estimated deaths has remained somewhat stable. The ratio of registered deaths to the estimated number of deaths varies a great deal across the Indian States, due to a systematic bias in big cities that have healthcare. This strengthens the case for the proportionality assumption being hugely problematic.

However, a thorough analysis of the death data from the Civil Registration System (CRS) has frequently shown grave flaws.

This suggests that mortality data from the CRS is not a trustworthy source of death until adjustments are done for sex, age, and location, which is largely to establish the baseline estimates before the pandemic compared with registered death data during the epidemic. Reiterating that in 2019, the CRS reported registering 7.64 million deaths overall, or 92 percent of the total fatalities estimated by the Sample Registration System (SRS) is crucial, as shown below in Figure 2.

2. "Five points about the second wave" – Business Standard https://www.business-standard.com/article/opinion/five-points-about-the-second-wave-121050701470_1.html.

Figure 2. Estimated Deaths and Registered Deaths in India



Source: Author's estimation.

However, the total number of deaths in 2019 was 9.92 million when age, gender, and location adjustments were performed. After accounting for age, sex, and location, the overall level of registration (LOR), or completeness of death data, was therefore 77 percent, which was 15 percent higher than the previous year. Researchers C. Rao et al., for instance, demonstrated that the CRS data on deaths (7.64 million) undercounted the number of deaths by 2.28 million for 2019 (prior to the pandemic). This undercounting was systematically worse for the elderly (over 60 years old) and children (under five years old), who accounted for 56 percent and 30 percent, respectively, of the additional deaths. They also discovered, not surprisingly, that changes in the States of Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh were responsible for 75 percent of the extra deaths.

The household survey, such as the C-Voter tracking survey, is another data source that academics have used to calculate the number of extra fatalities. It is a daily nationwide poll that uses computer-assisted telephone interviews,

though its main objective is to monitor how people perceive the government, the media, and other social indices. The sampling strategy and the questionnaire were not meant to gather information on household deaths. In India, the Sample Registration System (SRS), a comprehensive demographic census, provides a trustworthy source of death statistics. Over 8 million individuals in all States and Union Territories are covered by it. Its main objective is to generate national and State-level birth and mortality rates. Unfortunately, the pandemic prevented the SRS survey from being completed. In comparison, the C-Voter tracker survey is a crude and inaccurate way for gathering data on deaths, with a coverage of 0.14 million adults and death counts relying on self-reported data from telephonic surveys without on-field verification. Furthermore, the low response rate raises important questions about non-response bias that are difficult to quantify.

Researchers made the assumption that respondents' responses to survey questions would not vary over time. Instead, increased media attention, general concern, and interest levels during the pandemic waves would suggest the potential of a range of reactions from the populace. For instance, during a wave, people would be far more attentive to the surroundings and occurrences than they are at other times. The estimates of excess deaths are seriously questioned because of these naive assumptions.

Due to the lack of precise fatality statistics, there has been a lot of political speculation. The fact is that India lacked a system for gathering accurate, real-time statistics on deaths even before the pandemic. No matter how sophisticated the statistical methodology, there is still no alternative for excellent quality data, which is the real problem, not whether the statistics are correct or incorrect. The rate of death registration in India increased significantly from 75.3 to 92 percent between 2015 and 2019 as a result of significant efforts to digitize the country. However, there are still a number of issues with this work in progress, including the startling 2.28 million deaths(or roughly 23 percent of all deaths) that were not included in the CRS mortality data even in 2019. With low levels of registrations, the situation was exponentially worse.

Overall, this is a very comprehensive paper, but for policy-makers to take it seriously, we will have to get down to the dirty details of data and the data systems that exist in India.

Sonalde Desai
University of Maryland and *NCAER*

West Wing, a TV Serial about a Nobel prize-winning Economist who becomes the president of the United States, has a line, "Economists were put on earth to make astrologers look good." We need to rephrase it to say that, "Epidemiologists were put on earth to make economists look good."

Predictions in response to COVID-19 do not cover any segment of the research community with glory. We have been remarkably wrong in so many things! This paper does an excellent job of outlining some of these bloopers. Let me highlight the key findings and connect them to some additional observations:

1. When the United States failed to close its borders to its citizens returning from Chinese New Year celebrations in Wuhan, resulting in a rapid spread of SARS-CoV-2 in the US, the world took a lesson that closing down borders will stop the virus at our doors. Nonetheless, India's sharp clampdown around its borders did not stop the virus from entering India. The disease had already spread by the time travel restrictions were put in place.
2. The author, Anup Malani, notes that, perversely, the lockdown allowed the virus to breed within densely populated urban slums, leading to an extremely high infection rate.
3. The *mantra* of "Test, Trace, Track" that the international community repeated was ineffective because many infected individuals were asymptomatic and could not be identified. While there is some hope that governments can track and quarantine symptomatic individuals and their known contacts, asymptomatic individuals continue to spread the virus. Quarantining, of course, has the perverse effect of reducing the willingness to be tested. The author asks us to focus on super-spreaders, but how can we identify these people? Moreover, "super-spreader" is not a politically innocuous term. In the US, it applied to Chinese immigrants, and in India, to Muslims initially following the Tablighi Jamat incident. In both cases, it led to substantial discrimination.
4. Disease modelling had some success in the short run, but in the long run, it was ineffective because the data needed for robust modeling were not readily available. Moreover, as the author notes, political sensitivities and interference made it difficult to develop good forecasting for effective policy development. Hence, we continued to operate in the dark, toying with full lockdowns, limited lockdowns, and containment zones.

The lesson suggested in the paper is that we need better data, more timely data, more diverse data, and more sophisticated, homegrown modeling. This is a very thoughtful and practical paper in which the author makes several recommendations, which I want to group into four as follows:

1. The forecasting models need to improve.
2. To do that, we need better data. We should encourage the collection of better data from individuals and governments. The author mentions some interesting data collection efforts that he has been involved in, such as

testing for seroprevalence. He also notes that we should increase the incentives for individuals to get tested so that our COVID prevalence data is based on a representative sample and not on sick individuals.
3. We need the government to stop being secretive and controlling, and let diverse groups work, let the data be publicly available, and trust the public not to create a panic.
4. We should link economic data to disease surveillance.

If I were to lay out a future research agenda, I cannot imagine doing a better job. He covers diverse terrain, except perhaps collection of behavioral data that would facilitate agent-based modeling, so we don't just have to rely on SIR models or their variants. But much as my researcher's heart palpitates at these exciting opportunities, I am not sure that we are offering policymakers sufficient guidance on preparing for another pandemic, even when it comes to the data they need to make decisions.

Almost certainly, the R_0 for any new virus will be different; it will affect other sections of the population, and antibodies may last longer or shorter than SARS-CoV-2. It may or may not mutate as quickly as SARS-CoV-2 has done. Fatality caused by that virus may be higher or lower. So, future policymakers will benefit as much from our current experience as we did from the Spanish Flu of 1918.

Even research based on the author's favored method, that is, seroprevalence studies, highlights the limited predictive power of these studies between the Alpha and the Delta waves, as the virus continued to mutate.

The following two examples are illustrative:

1. A seroprevalence study of approximately 28,000 participants selected from 274 wards in Delhi was carried out in January 2021 (Sharma et al. 2021). The sample was selected using a systematic multi-stage sampling procedure that should allow for a random example of people ages five and above in the Delhi area. Venous blood samples were collected and transported to a lab to be analyzed using the VITROS® (Ortho Clinical Diagnostics, Raritan, NJ, USA) assay (90 percent sensitivity, 100 percent specificity). Seroprevalence of Anti-SARS-CoV-2 antibodies was about 50 percent for the population and 56 percent after adjustment assay characteristics. Antibodies were detected in almost all sections of the society, including the young, old, male, female, and slum-non-slums. In the light of this implied widespread immunity, the sharp spread of the COVID-19 Delta variant and the concomitantly high death toll barely three months after this study comes as a surprise.
2. One might say that 50 percent does not signify herd immunity yet. But a study from Manaus in Brazil (Sabino et al. 2021) published in *The Lancet* found that even a seroprevalence of 76 percent in October 2020 was

insufficient to protect the population from the Delta wave by March 2021. This may be because the immunity may have waned quickly or because the Delta variant was able to evade immunity generated by a previous infection.

Whatever the reason, we know now that despite very high levels of seropositivity, most populations worldwide, particularly in India, succumbed to the Delta variant of COVID-19 with tragic consequences.

So, what is a policymaker supposed to do?

Although we hope and pray that this was a once-in-a-lifetime event, we do not need to be Bill Gates to believe that a recurrence of a similar or even more virulent pandemic is possible and that lightning could strike twice. Moreover, pandemics are not the only emergencies nations face. Some of the discussion below also applies to other catastrophes such as earthquakes, floods, and other calamities that bring their own destruction of lives and livelihoods.

Instead of turning the present experience into advocacy for more and better data for the same kind of modeling, let us start from a clean slate and develop some governing principles for future policymakers and then ensure we have sufficient data to support these decisions.

1. **Early warning of potential threat and severity of this threat will be helpful.** Unless the virus originates within our national boundaries, we will need international collaboration to get an early warning about the emergence of a new virus, its characteristics, and the severity of its impact. India should use its Presidency of G-20 to lobby for an international network and protocol for data-sharing that does not rely on WHO but where scientists can talk to each other. We also need to give up our faith in Indian exceptionalism and assume that unless proven otherwise, any disease that strikes Sweden or Uganda will have similar features if and when and it reaches India. A good example is how relying on the UK experience allowed India to spread vaccination and vaccinate a large proportion of the population during a vaccine shortage.
2. **Move from a singular focus on prevention to management.** Our COVID-19 prevention strategies were rooted in our experience with HIV/AIDS. The only way to prevent the spread of HIV is to undertake behavioral change. But COVID-19 spread through the air, not through specific contacts like sexual relations or needle exchange. Density makes it challenging to prevent impersonal communication. Hence, instead of putting all our eggs into the prevention basket for a future pandemic of an unknown nature, we should also figure out how we will manage the symptoms and reduce long-term complications. From a data perspective, developing a management system that identifies trained personnel and equipment such as ventilators and cold boxes will help mobilize a quick response. The present pandemic has helped us create a variety of

management systems. Building on these to track inventory and trained personnel would help address future emergencies.

3. **Develop processes for delivering welfare benefits quickly.** During emergencies, delivering welfare is difficult. Hence, we often end up providing benefits to people who are part of our system, regardless of whether they are the neediest ones or not. The Indian Government sent out advance payment of PM-KISAN, transfers into the Jan Dhan account, and additional rations. All are very welcome. However, as the plight of migrants walking back to their hometowns showed, they were not part of the system through which they could receive these benefits. Many did not have ration cards, and hence could not get extra rations. Our method of delivering benefits was akin to looking for the key under a light pole rather than where it was lost because we had to rely on existing registration systems. This experience shows the importance of developing a comprehensive, location-linked social registry that could be quickly activated to provide benefits to the targeted beneficiaries, be they in cash or kind. Given the privacy concerns, this registry will need to be voluntary.
4. **Develop a sophisticated decision matrix for identifying the potential risks and benefits of a lockdown.** Early epidemiological models from institutions like the Imperial College and Institute for Health Metrics and Evaluation (IHME) generated a sense of emergency that led governments to implement severe lockdowns in many cases. However, the lockdown is a blunt instrument that can be used in the short run to prepare for a better response to upcoming emergencies. Still, its indefinite continuation creates a very different crisis. School closure provides an exciting example. Arguably the most significant long-term consequences of the pandemic will come from learning losses associated with school closures. Even after travel was allowed, lockdowns were eased, and economic activities resumed, schools remained closed. India has some of the most extended school closures worldwide and even in South Asia.

We need to know whether these school closures were justified from a health perspective before trying to balance health risks against learning losses. Understanding the disease consequences of various school closure policies may be worthwhile. Research on Sweden offers an exciting example. At the onset of the pandemic, Swedish upper-secondary schools moved to online instruction, while lower-secondary schools remained open. This allows for a comparison of parents and teachers differently exposed to open and closed schools but otherwise facing similar conditions. A careful analysis by Swedish economists published in PANAS (Vlachos et al. 2021) shows that parents matched on everything except having children in lower secondary versus upper secondary schools show similar levels of PCR-confirmed infections. Perhaps the virus carried by their children was not their only source of infection. The study did

not include tests on children. Still, given the correlation of infectivity within families, there is a good chance that parental infection is a good proxy for child infection. Teachers in lower secondary schools who delivered in-person instruction were more likely to be infected than teachers in upper-secondary schools. However, school closures were mandated on the grounds of student health rather than teacher health since teachers are often counted as essential personnel, and teacher health would need to be treated in the context of other high-risk occupations such as grocery store clerks, bus drivers, and Amazon delivery personnel. Whose health concerns should dominate decisions regarding school closures? These are the questions worth exploring in developing a pandemic preparedness plan.

I want to end by acknowledging the enormous uncertainties under which policymakers operated throughout the pandemic. No one knew what we were dealing with at the start of the pandemic. We did not know how rapidly COVID-19 would spread, how virulent it would be, how successfully we would develop vaccines, and how best to produce and administer the vaccines. Operating in the dark, the nation and its leaders did their best. The Government recognized the seriousness of the pandemic and tried to act swiftly; the population rallied around the need for harsh lockdowns. NCAER's studies in Delhi showed that in April 2020, nearly 85 percent of the respondents supported the lockdown, and 66 percent continue to believe even after a year and a half of its imposition that it was the right decision. Individuals modified their behaviors and voluntarily tried to reduce social contacts, even in crowded slums where this is difficult.

Most importantly, vaccine development, production, and delivery have been remarkably successful, and India can take justifiable pride in this achievement. However, we also saw some tragic consequences caused by the lack of hospital facilities and ventilators. The social and economic impact was severe to begin with, and may have long-term effects for learning losses. Treatment sometimes brought other complications, such as steroids leading to black fungus.

Thus, a discussion like this is vital in preparing for future pandemics and other calamities. I congratulate the author, Professor Anup Malani for his thoughtful reflections on this paper.

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General Discussion

The Chair, Surjit Bhalla, commended the fascinating and valuable paper and said that it raised a critical research question: What data do we act on? Obviously when the COVID-19 pandemic hit, everybody wanted information, but there were no data except on the plague in the past, which of course, was vastly different. Some of the papers cited clearly needed further research. He urged the research community to be more diligent while conducting their research on such issues to prevent skepticism about their findings among the public. It is also important to act on all the available information to avoid paralysis on action. One of the suggestions the paper made is to further research, as the big payoff for research is that we can get to the action faster. But we should refrain from criticizing the authorities as they were doing the best they could based on limited knowledge. As regards the author's suggestion on the need to attain more collaborative data, the World Health Organization (WHO) was already doing that efficiently.

Ruchir Agarwal raised some important policy points and issues for the research agenda, as the head of the IMF's Pandemic Response Task Force. The first was a backward-looking point. During the peak of the Delta wave of the pandemic, the number of cases in India was 400,000, as on 7 May 2022. However, cases were already rapidly rising in Maharashtra about 4 to 6 weeks before that. He suggested that it would be a great case study to bring together academics and government officials to understand what did not work well and how things can be done better the next time. That agenda does not require modeling, it just requires more effective coordination across States. The forward-looking points are as follows: First, COVID is going to be with us forever, and its impact in India will continue in future. Just as Dr Sonalde Desai talked about the long-term effect of school closure during the lockdown, he also flagged the effects of long COVID, especially its long-term effects on health.

Second, COVID will not be the last pandemic. So, this is an opportunity for us to build a health-strengthening system agenda at the local level that is coordinated at the national level, based on the lessons learnt during the COVID pandemic, such that when the next pandemic happens, regardless of the nature of the pathogen, we can handle it better based on the lessons learnt during COVID and hand over that knowledge to the next generation.

Devesh Kapur pointed out that in 2021, the Supreme Court had announced that everyone who died of COVID would get a cash payment. He asked if

anyone had looked at the data on how many people had made claims to get this money, as such claimants would have to give details on deaths, and that could be an alternative or additional source of data, as clearly there is an incentive for people to claim the money. He also asserted that whenever there is an occurrence like COVID, the main attention is on the national government. But public health is constitutionally a State subject. So, what did this tell us about how much States prioritize public health? One way to address this issue is to examine the State budgets in the most recent year and look for any differences in public health spending.

Shamika Ravi averred that she could speak for one State, Madhya Pradesh, because she was working with them. She revealed that the State had recorded a 35 percent increase in the health budget in the last two years, which is almost entirely because of the pandemic. Although Madhya Pradesh is a poor State and amongst the bottom four in terms of per capita income, it was surprisingly in the top four when it came to the vaccination drive. This indicates that the State government has realized that they have the means, or at least the governance architecture, through which they can get some basics right. There is a task force which is monitoring data on the neonatal mortality, infant mortality, and maternal mortality, largely looking at maternal and child health, and that whole initiative has ostensibly happened thanks to the pandemic. There is also a growing awareness about the need for ensuring such interventions in the health sector. The second issue pertains to the Ayushman Bharat scheme, on which the National Health Agency (NHA) has data. It is not really driven by the Supreme Court ruling. The Government may contest that ruling, as it has huge fiscal implications, but the data with the NHA will be able to show if it is an alternate and efficient way to measure the death numbers. There is also an incisive paper from the Insurance Regulatory Development Authority (IRDA), which looks at insurance claims around this time. She also remarked that the C-voter survey basically assumes that the compliance or the response rate in the survey is going to be the same in the middle of the Delta wave as it was before. This survey therefore leads to biased estimates.

Mridul Saggar wanted to know how exactly the author was measuring the lockdowns, in terms of the database used and the availability of other databases. He said that researchers were mostly using the Oxford Stringency Index, which is not a very reliable measure because it just takes the maximum restrictions in a particular city at a point of time. It virtually gives no idea and probably any research based on that would be completely misleading.

Ram Singh noted that the author was arguing against an official government monopoly over disease data and by implication, in favor of private ownership of the data. If the idea is to ensure that private entities own and use disease-related data in the presence of a lot of uncertainty about how data or any given data could be read and interpreted, it could make governments even less receptive to what one makes of that data.

Neeraj Kaushal stated that lockdowns would have different impacts, depending on whether they were imposed at the beginning of the pandemic or at a later stage during the pandemic. This is a highly endogenous and not an exogenous policy. The human and public policy response to it is not exogenous. So, some of our interpretations have to do with the way the policy has been implemented, depending on the kind of lockdowns. She asked if there should have been school lockdowns, and whether business lockdowns would have had a different kind of impact. Hence, any generalized statement about the impact of lockdowns in one particular country, and whether it would have the same kind of impact in another, is probably an exaggeration.

Arokiasamy Perianayagam commented on the discussion on counting excess mortality deaths of COVID. There are lot of estimates floating around. Different authors have proposed different estimates, and the number may be 4 million, or 5 million, or 3 million. According to WHO estimates, it is 3 million. The best way to get an answer to resolve this is to refer to SRS data. Say, the current count or pre-pandemic count is 8 million, we would have to wait for the next round of SRS data, and it could take another two years to get data for the period 2020-22. If the SRS data comes out with mortality estimates, then we will know the correct number of excess mortalities. The other option is that we have very good health survey platforms, such as the DHS, which is equivalent to the National Family Survey, India, and other health survey platforms like the one at the National Sample Survey Organization (NSSO). They do a highly robust sampling of methodology platforms, which can be used to do a quick survey, to add a component of mortality as a couple of retrospective questions on mortality in the last two years, and ask about the active component of the WHO verbal autopsy model, which has been implemented in many surveys. This sort of a scientific survey will provide a very reliable estimate of excess mortality, and demographers are adept at assessing these numbers on mortality and fatality. That is thus the best way for resolving the mortality data question.

Sonalde Desai responded to Ram Singh's comment on the debate on public data versus private data. She said that she is a big believer in private data collection and triangulating with public data, during the pandemic we are dealing with a very different situation. She pointed out many researchers had been doing telephone surveys at NCAER during the pandemic. It was very easy to do surveys during the first lockdown because nobody was sick. People were sitting at home, and were very willing to answer the questions. But NCAER researchers did not want to do the survey during the Delta wave because when people are under tremendous distress, that is not the point at which they would want some social scientist calling up to get the data. That also applies to a lot of issues associated with pandemic data. For instance, people who had a death in their household are not going to want to answer your questions, and researchers should not even be bothering them. We have to take our data collection tasks, private or public, with some level of humility, particularly during times of such an emergency.

Surjit Bhalla concluded the discussion by advising the research community to be humble because the real fact about the pandemic is that the whole class had failed and they are not willing to admit it. This includes all the major institutions in the world that are supposed to help public policy, including the WHO and the Center for Disease Prevention and Control (CDC). In December 2019, the CDC published research based on the last 70 years of pandemics, saying that masks and social distancing do not matter. There may not be evidence even now that these two things matter. But, there was a failure on the part of all the stakeholders.

As regards the suggestion on preparation for the next pandemic, economists certainly have to worry about the benefit cost of preparing for the next pandemic, and each country has to do the cost-benefit analysis. Given that a pandemic is a public bad and information flows very freely, why should India be investing in preparing for the next pandemic rather than improving its health care and taking care of non-pandemic related illnesses and deaths and diseases?

He also asserted that the pandemic had thrown up a critical and interesting finding. Developing countries, on average, have much worse health care systems. They are poor and are not so careful. Advanced countries are the most careful, have the best advance health systems, and the best economists and the best modelers. Yet, all the data, including the most robust statistics, show that developing nations had a much lower incidence of COVID-19 and much fewer deaths, even after accounting for the number of excess deaths, than their advanced counterparts. He said that he had asked this question to international organizations too—they do not have an answer or they do not care to answer. We also have to recognize that unfortunately, the pandemic led to extensive analyses, large-scale prescriptions of drugs, and a heavy dose of ideology and politics. In his opinion, this was because everyone was searching for answers to deal with one of the deadliest pandemics in human history, leading to massive tragedies around the world.

Lastly, he advised the author to highlight in the paper two major successes of the Indian Government, that is, its extensive COVID vaccination drive across the country, and its efforts to help migrant workers and the poor through various welfare schemes for food distribution and monetary support to alleviate the misery of poor households and enable them to tide over the livelihood crisis created by the pandemic.

The session video and all slide presentations for this IPF session are hyperlinked on the IPF Program available by scanning this QR code or going to
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AMIT K. KHANDELWAL*
Yale University & NBER

The US-China Trade War and India's Exports§

ABSTRACT Between 2018–19, the US and China engaged in a trade war that targeted roughly $450 billion in bilateral trade, abruptly changing market conditions for thousands of internationally traded products. Was India able to capitalize in this new global environment by increasing its exports? The short answer is: not really. The trade war did not statistically impact India's overall exports. So, the prediction that India could benefit from the trade war did not materialize. These results hopefully contribute to ongoing policy discussions for how India can leverage export opportunities in an era of increased trade tensions.

Keywords: *US-China Trade War, India*

JEL Classification: *F0*

1. Introduction

In 2018–19, the US and China engaged in a trade war that targeted $450 billion in bilateral trade. The war ran counter to a multi-decades long endeavor that lowered trade and non-tariff barriers across the globe, and the share of US GDP targeted by tariffs was more substantial than the Smoot-Hawley tariffs (Fajgelbaum and Khandelwal 2022). Market conditions for thousands of internationally traded products were upended, and analysts made predictions for how the trade war, and rising trade tensions more generally, would affect global trade. A common presumption among many businesses and policymakers was that "bystander" countries would benefit from the trade war as US and China reduced exports into each other's markets. The early reaction in the press suggested that India would benefit from an indirect improvement in

* *amit.khandelwal@yale.edu*

§ Nikhil Basavappa provided excellent research assistance, and the author would like to thank Maximilian Schwarz for invaluable data support for this project. He also thanks Pablo Fajgelbaum, Pinelopi Goldberg, and Patrick Kennedy for helpful conversations with this draft, which is an offshoot of their joint project, Fajgelbaum, Goldberg, Kennedy, Khandelwal, and Taglioni (2021). Pravin Krishna and Prachi Mishra provided excellent comments on the draft. All errors are those of the author.

access to the two largest markets in the world (see, e.g., *Financial Times* 2019; *Economic Times* 2019; *CNBC* 2019).

This paper provides an answer to the question: Did the trade war increase India's exports? Although it is natural to think that bystander countries would benefit from the tariffs, the extent to which a country like India could capitalize depends on several demand and supply forces. On the demand side: Do American and Chinese consumers perceive India's exports as substitutes with Chinese and American exports, respectively? If so, India's exports to these two markets would increase. But, if India exports goods that are complements to US and Chinese goods, the trade war would reduce its exports to these markets. On the supply side: Did the tariff increases coincide with India's existing comparative advantage products? If not, taking advantage of the tariffs, at least initially, would be difficult. On the other hand, perhaps an improvement in market access would benefit India's more marginal products. In either case, the response hinges on the extent to which India could reallocate factors of production into the targeted products. Moreover, Indian companies would need to overcome existing non-tariff barriers—regulatory hurdles, trade financing, rules of origin requirements, quality standards—that did not change during the trade war. Even if reallocation into US and China was seamless, would it come at the expense of exports to the rest of the world? If so, India's global export growth would be unchanged. Additionally, the trade war triggered a large cloud of uncertainty around economic growth and the future of globalization. The uncertainty could have blunted Indian companies' investment plans, and/or affected decisions by foreign Multinational Corporations (MNCs) to invest in India. On the other hand, at least in the summer of 2018, analysts had blamed India's currency devaluation on the trade war tensions, and this devaluation could have benefited exports (*Financial Times* 2018). Finally, other bystanders faced the same forces and tradeoffs, and so even if India could take advantage of the trade war, the response by other countries, like Vietnam, Malaysia, or Mexico, could crowd out India's gains.

A formal framework developed by Fajgelbaum et al. (2021) clarifies how these demand and supply-side factors shape a bystander's response to the trade war. If a bystander country like India exports products that are substitutes for Chinese exports, then the tariffs induce a positive demand shock and India's exports to the US would rise. But, if India exports goods that complement China, then India's exports to the US would fall. India's global export response, however, hinges on its ability to re-allocate into the targeted goods. If India's exports to the US increase (because it substitutes for China) and its supply curves slope upwards, exports to the rest of the world would fall and exports globally may not change. On the other hand, if supply curves slope downward, potentially due to economies of scale, then the export increases to the US would lower marginal costs and drive an export increase globally. The framework can, therefore, rationalize any impact of the tariffs on India's export responses to the

US, China and the rest of the world (RW) according to underlying primitives of demand and supply parameters. Conveniently, the framework yields transparent and straightforward estimating equations that are easily taken to the data.

This paper examines India's response to the trade war from 2018–19. I analyze India's product-level trade data that cover the universe of its non-service exports.[1] During that period, the US raised tariffs on Chinese exports in 4,413 six-digit Harmonized System (HS) products by an average of 23.1 percent, and China raised tariffs on US exports in 4,422 products by an average of 29.4 percent. Collectively, these two sets of tariffs covered 98.5 percent of India's (pre-war) exports. The two countries also changed tariff rates on bystander countries. The US raised tariffs on India's steel and aluminum products and removed India from the Generalized System of Preferences (GSP) in May 2019. On the other hand, China reduced its Most-Favored-Nation (MFN) tariff rates on bystander countries, so India faced lower tariffs on its exports to China. Together, these four sets of tariff changes constitute the "trade war", and I examine how they affected India's export response to the US, China, and RW. Through the lens of the model, the results offer insights into the underlying demand- and supply-side forces that drive India's trade. Moreover, the product-level responses can be aggregated to the overall country response to provide a summary of how India's exports responded to the trade war.[2]

The main takeaway of the analysis is that India's aggregate export response to the trade war was quite noisy. While there are particular tariffs that affect particular destinations more sharply, I estimate that the trade war increased India's exports to the world by 1.7 percent with a large standard error (se) of 3.6 percent. Thus, I conclude that the trade war did not statistically change India's global exports.

Disaggregating the response by destination, the trade war decreased exports to the US by 7.7 percent (se 6.0 percent). This decline is surprising, since the underlying coefficients suggest that India exports products that are substitutes for China's. However, there is a large negative impact of the direct tariffs that the US imposed on India, and it appears that US demand for Indian intermediates fell. India's exports to China in response to the tariffs are essentially flat, increasing by only 0.3 percent but with a very large standard error of 12.1 percent. There is evidence that India's exports to RW increase,

1. The trade war changed tariffs for only non-service products, and due to data limitations, I am unable to examine whether or not there are spillovers to India's service exports. I do not include exports from 2020–22 because the pandemic is likely to have confounded the impact of the trade war.

2. An important caveat to this aggregation exercise is that it controls for general equilibrium forces that operate at a higher level than what is controlled for by the econometrics specifications; for example, the trade war's impact on the rupee, which may affect exports across all products. In other words, the aggregate exercises I perform are based on regression specifications that compare export responses among products more affected by the tariffs relative to those less affected, controlling for sector fixed effects.

although the impacts are again noisy: exports increased by 4.2 percent (se 4.4 percent). Setting aside the noise, through the lens of the model this pattern suggests that India operates along textbook upward-sloping supply curves. So, any change in exports to US and China would be offset by export changes to RW. In short, there is no evidence that the trade war changed India's global exports on a statistical basis. Excluding the direct impacts of the US tariff on India and China's MFN reductions to focus exclusively on the impacts of the US-China tariffs does not qualitatively change this message.[3]

To put these numbers in perspective, using the same data and model, the trade war increased global exports for Indonesia (10.2 percent, se 5.6 percent), Malaysia (7.7 percent, se 5.4 percent), Mexico (11.3 percent, se 4.0 percent), Thailand (8.1 percent, se 5.1 percent), Turkey (13.9 percent, se 4.8 percent), and Vietnam (13.9 percent, se 5.0 percent).

Given the large standard errors, it is natural to conjecture that there is heterogeneity in the responses to the tariffs by sectors or product characteristics. Heterogeneity can exist along many possible dimensions, and I discipline the analysis by considering dimensions that are policy-relevant. But, across nine broad sectors, I continue to find a noisy response to the tariffs. The two exceptions are the apparel and transport sectors, where there are large increases in global exports of 19.2 percent (se 9.1 percent) and 60.8 percent (se 30.6 percent). But, overall, the impact on exports remains noisy once allowing for sector-specific tariff responses. Next, I consider heterogenous responses in products at the right tail of product size, comparative advantage, technology, and capital intensity. I also consider various measures of products' position in supply chains based on various measures proposed in earlier work. Along both sets of heterogeneity, I do not find sharp impacts of the tariffs. The lack of clear findings in the latter case is consistent with the claim that India, at least relative to its neighbors in East Asia, has difficulty integrating into manufacturing global value chains.

Finally, I use customs data that track firm-level exports during the trade war. While there are caveats to these data, they similarly confirm the noisy response of India's exports to the tariffs. But, one point of optimism is that there is some evidence that the tariffs triggered entry of firms into product lines, particularly for firms' exports to RW.

The overall disappointing lack of response should contribute to ongoing discussions regarding India's export strategy. What is distinct about the US-China trade war is that market conditions changed suddenly for India's exports

3. In a concurrent and very related paper, Sanyal (2021) finds that India's exports to the US respond positively to the US tariff and negatively to the direct tariff increases, as I find here. He, too, finds relatively noisy responses of the other tariffs on exports to China and the RW. That paper does not provide an aggregation over the different tariff responses making it difficult to compare with the aggregate responses reported here.

without India's consent. Thus, the normal considerations that weigh into bilateral or regional trade agreements—tariffs and non-tariff barriers, national security, and political factors—do not apply here. To be sure, India has recently been active in pursuing trade agreements outside the World Trade Organization; Krishna (2020b) discusses the 17 bilateral or regional agreements that India signed between 2007 and 2017. More recently, after a heated policy debate, India chose to not join the Regional Comprehensive Economic Partnership (RCEP) Agreement in 2020, but is currently negotiating bilateral agreements with the UK, European Union (EU), Australia, and Canada. Panagariya (2008; 2019), and Krishna (2020a) are comprehensive sources that analyze India's past and recent external policies.

However, how India responded to the trade war should be of interest to policymakers given rising tension around the globe: Brexit, the US-China trade war, the COVID-19 global pandemic, the Russia-Ukraine conflict, and rising tensions in the South China Sea. Can India benefit when market access deteriorates between other countries? The question here is somewhat related to one posed recently by Chatterjee and Subramanian (2020), who asked if India had taken advantage of export opportunities indirectly created by China's growth and development as it exited low-skilled exports. They conclude "no" because of India's deteriorated export competitiveness after the financial crisis and its under-performance in low-skilled intensive sectors. The trade war poses a similar question: did India take advantage of an indirect improvement in export market access? The results also suggest that India's response was quite mixed.

The lackluster results suggest that domestic policies may be important to address if India's non-service exports can capitalize on tensions between other countries. Atkin and Khandelwal (2020) and Atkin and Donaldson (2021) review the recent work in trade and development and demonstrates how distortions in low-income countries—weak rule of law, credit constraints, informality, size-dependent distortions, and political connections, and so forth—affect trade in low-income settings. The message on the importance of reforming domestic distortions for international trade outcomes echoes the pioneering work by Bhagwati (1971), Bhagwati and Srinivasan (1975), and Krueger (1984). This paper does not explore the precise domestic reforms necessary to change the trajectory of India's trade outcomes, but serves as a reminder that more work is necessary.

The rest of the paper is structured as follows. Section 2 provides a background of the trade war and the data. Section 3 provides an overview of the framework developed by Fajgelbaum et al. (2021). Section 4 presents the results, and Section 5 concludes.

2. Trade War Background and Data

2.1. Background

The opening rounds of the US-China trade war began in February 2018 when the US imposed tariffs on solar panels and washing machines. In March 2018, the US further targeted iron, steel and aluminum products. These initial tariffs waves were not focused on China; instead, they targeted virtually all countries that exported specific products. However, over the next year and a half, the US successively imposed tariffs on imports from China in five waves: July 2018, August 2018, September 2018, June 2019, and September 2019. At each stage, China retaliated by raising tariffs on US imports. By the time a truce was announced in January 2020, both countries had collectively targeted $450 billion in cross-border trade flows.[4] Across all trade partners, the US had imposed tariffs of 17.6 percent on its 2017 imports, or roughly 2.6 percent of its GDP, with average tariffs increasing from 3.7 percent to 25.8 percent. Trade partners imposed retaliations of 8.7 percent of US exports, corresponding to about 1 percent of its GDP with average tariffs increasing from 7.7 percent to 20.8 percent. Fajgelbaum and Khandelwal (2022) indicate that the 3.6 percent of US GDP targeted exceeds the 1929 Smoot-Hawley legislation that targeted 1.4 percent of GDP. From China's perspective, tariffs affected an even larger share—5.5 percent—of its GDP.

Although the trade war was fought between the US and China, other countries, including India, were targeted during some tariff waves. India was hit with tariff increases on its metal products in March 2018. Justified by the Trump administration over national security concerns, Bown (2019) writes that India was hit with 25 percent tariffs on $761 million of steel and 10 percent tariffs on $382 million of aluminum products, which together accounted for roughly 2.3 percent of India's exports to the US in 2017. India filed a formal dispute within the World Trade Organization in May 2018 and threatened to retaliate on $1.4 billion of US imports (the threat did not materialize). The second tariff wave against India came in June 2019 when the Trump administration notified India of its removal from the GSP program. The GSP program is the largest and oldest trade preference program of the US, established in 1974. It was designed to give low-income countries preferential access to the US markets by eliminating tariff rates on their imports of eligible products. India's removal meant that it would now face the MFN tariff rate in these products to the US.

On the other hand, while the US was raising tariffs on selected products from its (non-China) trade partners, Bown et al. (2019) found that China was reducing its MFN tariff rates on its (non-US) trade partners. Thus, access to China's market improved for bystander countries vis-à-vis the US.

4. Readers interested in details of each tariff wave and the US-China Phase I trade agreement are encouraged to consult the excellent piece by Bown (2021).

2.2. Data

I analyze India's exports using the UN Comtrade database which records India's trade flows at the HS6 product level. These data track annual bilateral flows for India's exports across countries in 5,203 potential HS6 products. To focus on long-run impacts and to smooth out annual fluctuations, I aggregate the data to biennial (24-month) intervals, 2014–15, 2016–17, and 2018–19. The notation 2018–19 means the sum of 2018 and 2019 exports.[5] The analysis focuses on export growth between 2016–17 to 2018–19, with 2014–15 used to assess the pre-existing trends.

TABLE 1. Summary Statistics of India's Exports

Industry	*Examples*	*Value*	*Share (%)*	*# HS6*
Agriculture	Soybeans, wine, coffee, beef	27	10.6	831
Apparel	Footwear, t-shirts, handbags	38	15.2	907
Chemicals	Medications, cosmetics, vaccines	38	15.2	778
Machinery	Engines, computers, cell phones	23	9.3	771
Materials	Plastics, lumber, stones, glass	56	22.0	632
Metals	Copper, steel, iron, aluminum	22	8.9	560
Minerals	Oil, coal, salt, electricity	27	10.9	146
Miscellaneous	Medical devices, furniture, art	6	2.3	353
Transport	Vehicles, airplanes, parts	14	5.6	126
All Sectors		252	100.0	5,104

Source: Comtrade.

Notes: Table reports India's average 2016 and 2017 exports to the world, by sector. Sectors are defined by two-digit HS chapters: Agriculture (1-24), Minerals (24-26); Chemicals (28-38); Materials (39-40, 68-71); Apparel (41-67); Metals (72-83); Machinery (84-85); Transport (86-89); Miscellaneous (90-97). Values in USD billions.

I consider India's exports to three destinations: US, China, and a collective RW destination that aggregates over India's trade partners. HS6 products are classified into nine sectors: agriculture, apparel, chemicals, materials, machinery, metals, minerals, transport, and miscellaneous. Table 1 provides examples of products within sectors, and reports the share of India's worldwide 2016–17 exports across sectors. The US and China accounted for 19.2 percent and 5.6 percent of India's 2016–17 exports, respectively, with the rest of the world accounting for the remaining 75.2 percent. India's nominal export growth in 2018–19 was 13.8 percent whereas the inflation rate over this period ranged

5. I work with the HS2012 classification. I capture India's exports by HS6 through the mirror statistics of the imports of that HS6 code from India because Fisman and Wei (2004) suggest that import records may be of higher quality because importing countries have an incentive to collect tariff revenue.

from 3.7 percent and 4.9 percent (World Development Indicators). Figure A.1 reports product-level growth rates to the three destinations across sectors. The growth rates within sectors are quite heterogenous, making it difficult to discern if the subset of sectors particularly grew faster during this period. Below, I examine the impact of the tariffs by sector.

I supplement the analysis with firm-level customs records purchased from Descartes Datamyne for 2017 and 2019. These data record exporter identifiers, shipment values and product codes, and thus permit an analysis of the firm-level intensive and extensive margins.[6] There are a few caveats with these data, which is why I do not use them for the main analysis. First, these data do not capture the universe of India's exports. In 2017 and 2019, aggregate exports in these data were $212 billion and $283 billion, respectively, while aggregate exports in Comtrade total $294 billion and $323 billion. Table A.1 reports the aggregate statistics from each data source by year and destination, and the coverage of Datamyne in 2017 is lower than 2019. Notably, Datamyne data exclude exports from Free Trade Zones. Second, since exporter identifiers were missing for 45 percent of the records in 2018, I did not purchase data from this year. Thus, in contrast to the main analysis, which examines two-year growth rates that are smoother than annual rates, the analysis with Datamyne data covers growth between 2017 and 2019. Figure A.2 is consistent with this conjecture, which compares the product-level growth rates in Comtrade versus Datamyne data. The growth rates are positively correlated, but notice that the x-axis range is substantially larger with growth rates from Datamyne data. Given these caveats, I use Datamyne data to assess the firm extensive margin during the trade war, but derive the main results from (publicly-available) Comtrade data.

2.3. Trade War Tariffs

Since I work with biennial export changes, I scale the tariff changes in proportion to their duration within a 24-month interval such that, for example, a 20 percent tariff that is implemented for 12 months would be assigned a tariff rate of 10 percent = (20%*12/24). This scaling generates variation in tariff changes across products due to variation in both the magnitude of the rate changes as well as in the timing of when the tariff changes were implemented.

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6. According to the data provider, the export data is collected after Indian customs agents clear the shipment for export. The exporter identifier is taken from the customs declaration, but there are instances where the same company name reports different export identifiers. This could be because the company is shipping the item from different addresses or the company may have several subsidiaries within India. Determining the ultimate owner of each shipment is, in general, a major challenge with customs data. For the purposes of this project, I use a conservative approach that uses the exporter name as the identifier, after removing and standardizing the names to remove like "Limited," "Private," "ImpEx," and "Industries." This reduces the total number of exporters in 2017 and 2019 from 183,354 in the raw data to 152,086 after the trimming.

The trade war constitutes the following four sets of tariffs:

1. Tariff increases by the US on China (the "US tariffs," $\Delta T^{US}_{CH,\omega}$ where ω denotes an HS6 product code).[7] These tariffs affected 4,413 products with average tariffs increasing by 23.1 percent (or 9.3 percent in scaled changes). These tariffs covered 88.9 percent of India's (pre-war) exports.
2. Tariff increases by China on the US (the "China tariffs", $\Delta T^{CH}_{US,\omega}$). These tariffs affected 4,422 products with average tariffs increasing by 29.4 percent (or 11.3 percent in scaled changes). These tariffs covered 94.0 percent of India's (pre-war) exports.
3. Tariff increases by the US on India, $\Delta T^{US}_{IN,\omega}$, which include targeted products in steel and aluminum and the removal from GSP.[8] These tariffs affected 582 products with average tariffs increasing by 10.0 percent (or 2.9 percent in scaled changes). These tariffs covered 16.5 percent of India's (pre-war) exports.
4. Tariff decreases by China on all countries other than the US. Since I focus on India, I'll denote these tariffs as $\Delta T^{CH}_{IN,\omega}$. These tariffs affected 2,178 products with average tariffs decreasing by 4.5 percent (or 2.8 percent in scaled changes). These tariffs covered 49.3 percent of India's (pre-war) exports.

These tariff changes are taken from Fajgelbaum et al. (2021).

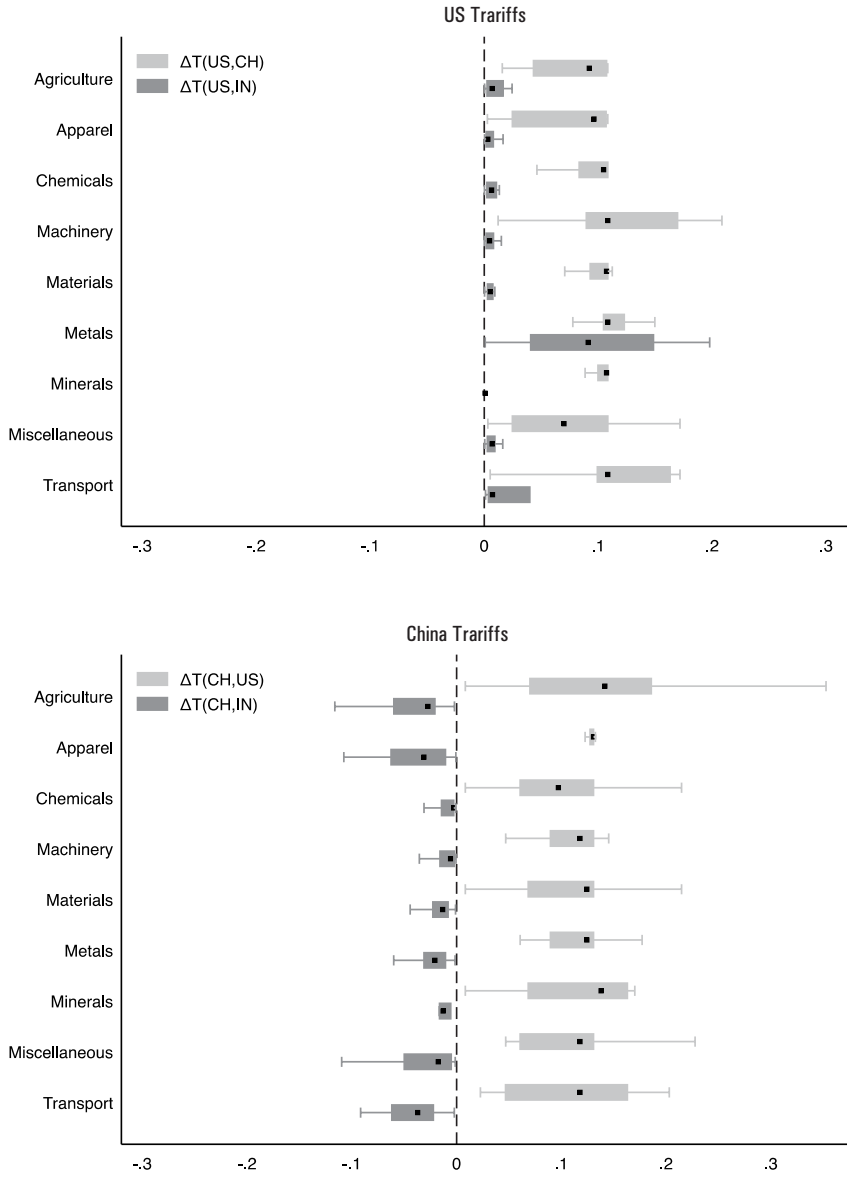
Figure 1 shows the variation in the four tariffs across sectors. The US and China raised tariffs on each other across most sectors, but the US tariff increases on India were concentrated in the machinery and metals sectors. The removal from GSP affected products in other sectors, but given the relatively low MFN rate, the magnitude of these tariff increases were not large. The bottom panel shows China's tariff reductions on non-US trade partners across sectors.

The bilateral US-China tariffs alone covered 98.5 percent of India's global exports. Thus, the trade war effectively changed market conditions for virtually all of India's 5,104 products that it exported prior to the trade war. There is a positive correlation between India's (pre-war) export shares and these US-China tariff hikes. The binscatter plot in Figure A.3 reports a positive correlation between 2017 product-level export shares and the average $\Delta T^{US}_{CH,\omega}$ and $\Delta T^{CH}_{US,\omega}$ tariff increases. Thus, at the beginning of the war, it seems reasonable to conclude simply from India's pattern of specialization that the trade war would be favorable for India. However, as discussed in the next section, a simple model of international trade that incorporates flexible preferences and supply responses reveals that a straightforward prediction of how India would benefit from the US-China trade war is difficult to make.

7. Throughout the paper, I define $T \equiv 1 + t$ where t is the statutory ad valorem tariff rate.

8. The source of product codes removed from GSP come from the official notification published on 5 June 2019, by Federal Register (2019).

FIGURE 1. Tariff Changes



Source: Fajgelbaum et al. (2021).

Notes: This figure is adapted from Fajgelbaum et al. (2021). It reports the set of tariff changes imposed by the US (Panel A) and China (Panel B), by sector. The tariff changes are scaled by total time in effect over the two-year window. For example, if the US raised tariffs on a product from China in September 2018 by 10 percent, the scaled tariff change over the two-year window would be 6.66% = (16/24) 10%. If the tariff of a product went up 25 percent in September 2019, the scaled tariff change would be 4.16% (= (4/24) 25%). The black dots indicate the median tariff increase, the boxes denote the 25th and 75th percentiles, and whiskers show the 10th and 90th percentiles.

3. Framework

This section outlines the framework developed in Fajgelbaum et al. (2021) to analyze the impacts of tariffs on bystander countries. The emphasis here is to provide the intuition for how tariffs between two countries may impact the economy of a third country, like India, and readers interested in the details of the model are encouraged to consult that paper.

The model is designed to interpret a country's response to the trade war tariffs across three destinations: US, China, and RW. The key insight is that the tariff changes will simultaneously affect a country's exports of product ω across all three destinations. The responses to each destination will depend on key parameters governing consumer preferences and production. On the production side, the framework assumes supply curves that could be positively sloped (the textbook case) or negatively sloped; the latter could occur if there are economies of scale in production, as analyzed recently by Costinot et al. (2019). On the demand side, the framework assumes that consumers have translog preferences. The use of this preference structure allows for dimensions of flexibility where consumers may value India's products relative to US or China differently than, say, Cambodia's products relative to US or China. Additionally, it allows for the possibility that India's products may complement Chinese exports, whereas Cambodia's products may substitute for China's. More formally, the semi-elasticities of India vis-à-vis the US and China will be different than other countries' semi-elasticities, and these semi-elasticities could either be negative (i.e., India's exports complement China) or positive (i.e., India's exports substitute China). A global trade equilibrium is characterized by a set of world prices that clear international markets. From that equilibrium, the model can then explore how a change in a tariff will affect a bystander's export allocation across destinations.

Consider how India's exports of product ω would change if the US imposes a tariff on China, $\Delta \ln T_{CH}^{US} > 0$. The tariff reduces China's exports to the US, a prediction confirmed by several analyses of the trade war (e.g., see Fajgelbaum et al. 2020). Consider India's export change of that product to the US, $\Delta \ln X_{\omega}^{US}$. If exports increase, this reveals that US consumers perceive India's varieties as substitutes for China's. So, if India is a substitute for China, the tariff change acts as a positive demand shock for India's exports in the US. What would happen to India's exports in this product to the rest of the world? If India's supply curve slopes upward, as standard textbook models typically assume, the increased exports to the US would accompany a simultaneous reduction of exports to the RW. Thus, when the US tariff increases on China, a response of $\Delta \ln X_{\omega}^{US} > 0$ and $\Delta \ln X_{\omega}^{RW} < 0$ would reveal that India is a substitute for China and operates along an upward sloping supply curve. On the other hand, suppose India's production supply for that product slopes downward. In this case, the positive demand shock in the US will simultaneously induce more

exports to RW, $\Delta \ln X_{\omega}^{RW} > 0$. In this case, global exports of the product would increase because of two forces: the product is a substitute for China and there are upward-sloping supplies.

The model shows that any combination of increases or decreases in exports to the US and RW are possible, depending on the sign and strength of demand preferences and supply responses. Likewise, the same would be true when considering India's response to China's tariffs on the US.

More formally, the model yields the following set of estimating equations to examine India's response to the trade-war tariffs across destinations n = US, CH, RW:

$$\Delta \ln X_{\omega}^{n} = \alpha_{j}^{n} + \beta_{1}^{n} \Delta \ln T_{Ch,\omega}^{US} + \beta_{2}^{n} \Delta \ln T_{US,\omega}^{CH} + \beta_{3}^{n} \Delta \ln T_{IN,\omega}^{US} + \beta_{4}^{n} \Delta \ln T_{IN,\omega}^{CH} + \varepsilon_{\omega}^{n} \quad (1)$$

where $\Delta \ln X_{\omega}^{n}$ is India's change in exports of product ω to destination n and α_{j}^{n} is a sector j fixed effect that controls for sector-level supply and demand shifters generated by the model. The coefficient β_{1}^{n} is the elasticity of India's exports to destination n to the US tariff on China. The coefficient β_{2}^{n} is the elasticity of India's exports to China's tariff on the US. The third term captures the impact of the US tariff changes on India. For n = US, this would be the direct elasticity of India's exports to the tariff change. For n = CH, US, it captures the indirect impacts of India's exports to those two destinations when the US raised tariffs on India. The fourth term β_{4}^{n} is the analogous elasticity that captures India's response to China's tariffs on India during the trade war period.[9] Fajgelbaum et al. (2021) show that these four tariff elasticities to each destination n depend on the underlying supply and demand parameters that are specific to each exporting country.

The specifications in Equation (1) call for running three separate regressions of India's exports to each destination on the four tariffs, with the HS6 products as the unit of observation. Identification of the coefficients comes from tariff variation across products within sectors.

Consider the interpretation of $\{\beta_{1}^{US}, \beta_{1}^{CH}, \beta_{1}^{RW}\}$, the coefficients on the US tariff across the $(\beta_{1}^{US} > 0)$ or complement for China $(\beta_{1}^{US} < 0)$. As also discussed above, the sign of β_{1}^{RW} reveals if India operates along upward $(\beta_{1}^{RW} < 0)$ or downward $(\beta_{1}^{RW} > 0)$ sloping supplies, on average across products. The coefficient on the US tariff in regression that examines exports to China, β_{1}^{CH}, captures two potential interpretations. First, analogous to the rest-of-world response, an increase or decrease of India's exports to China depends on

9. Fajgelbaum et al. (2021) show that the full model motivates two additional terms that capture India's response to the tariff changes of other countries. But since the magnitude of US and China tariff changes across bystanders were similar (in the case of China, the tariff changes were identical because China lowered MFN rates), there is not enough separate variation to identify these two additional terms.

the shape of India's supply of that product. A second interpretation concerns input-output linkages: if China's exports to the US decline because of the tariff and if India's exports of that product are used intensively by China as inputs, India's exports to China may also decline with the US tariff.

Consider next the interpretation of $\{\beta_2^{US}, \beta_2^{CH}, \beta_2^{RW}\}$, the coefficients on the China tariff across the three regressions. The sign of β_2^{CH} reveals India's substitutability or complementarity with US exports based on whether or not India's exports to China increase or decrease, respectively, with the China tariff. The coefficient β_2^{RW} reveals whether the tariff reallocated exports out of RW or exports production. The coefficient on β_2^{US} how the China tariff affects India's exports to the US, with the analogous two possible interpretations discussed in the previous paragraph. For example, exports to the US could fall with the China tariff if the US uses Indian products intensively as inputs.

The coefficients $\{\beta_3^{US}, \beta_3^{CH}, \beta_3^{RW}\}$ capture the response to the direct US tariffs on India. The sign of β_3^{US} is straightforward. It captures the direct impact of the tariff increases on Indian exports to the US. The other two coefficients, β_3^{CH} and β_3^{WR}, reflect potential expansion (or diversion) from China and the RW. An analogous interpretation lies with β_4^{US}, β_4^{CH}, β_4^{RW}: China's tariff reductions on India's exports will affect its exports to China, $\Delta \ln X_{\omega}^{CH}$, and there will be simultaneous reallocation from US and RW.

It is important to note that Equation (1) captures India's response along the intensive margin, i.e., exports in continuing products. I also analyze the extensive margin since the trade war tariff changes could have led to entry or exit of products, or entry/exit of firms within products. A second important note is the inclusion of the sector fixed effects, α_j^n. In the model, these fixed effects control for supply and demand shifters at the sector j level. In a fully-specified general equilibrium, these shifters themselves would respond to tariff changes. The analysis below controls for these changes and does formally account for how they may adjust. Thus, the interpretation of how the tariffs affect India's exports must be made with this important caveat in mind.

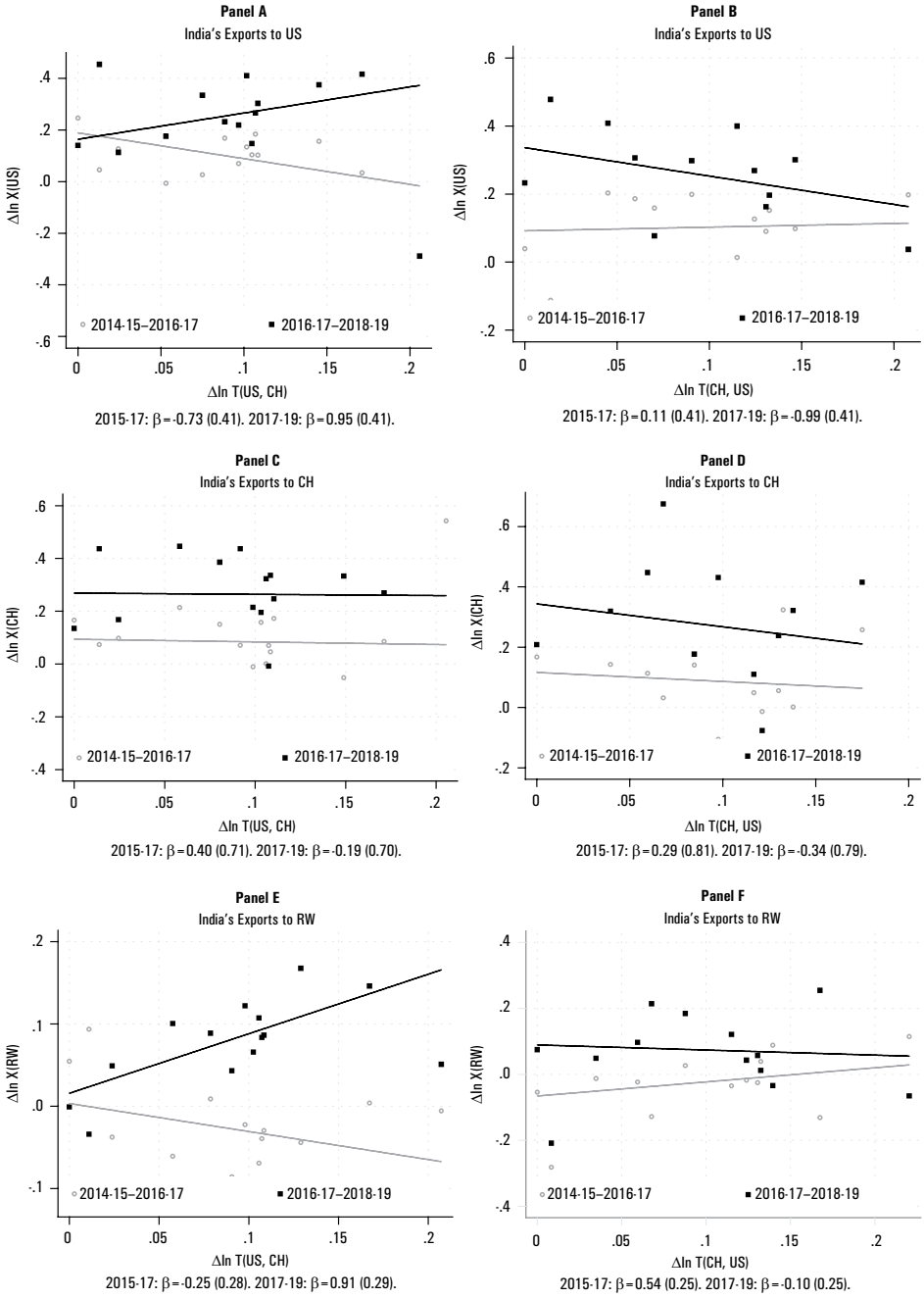
4. Results

I begin by assessing its pre-existing export trend growth to the US, CH, and RW. I then present the results from estimating (1), and end with a discussion of heterogeneous responses.

4.1. Visualizing India's Export Results

It is instructive to examine visually India's export response to four tariffs and to the three destinations. Figure 2 shows a series of binscatter plots, where

FIGURE 2. Tariff Changes



Source: Comtrade.

Notes: The panels show binscatter plots of India's export growth (on the y-axes) against changes in tariffs due to the trade war (on the x-axes; the left panel plots $\Delta \ln T^{US}_{CH,\omega}$ and the right panel plots $\Delta \ln T^{CH}_{US,\omega}$). Panels A and B show India's exports to US. Panels C and D show India's exports to CH. Panels E and F show India's exports to RW.

the y-axes show changes in India's product-level log exports and the x-axes show the US and China tariff changes. Each plot contains data points and linear trend lines from two periods: export growth prior to the trade war (2014–15 to 2016–17), and growth during the trade war (2016–17 to 2018–19). The former series helps assess potential pre-existing trends in India's exports that may have coincided with the tariff changes; the latter shows the export responses during the trade war.

Panel A plots India's exports to the US against the US tariffs. India's exports to the US increased sharply with the tariffs during the trade war, suggesting that the country took advantage of China's loss in market access along this tariff. Interestingly, India's export growth prior to the war happened to be slightly negatively correlated with the tariff. Panel B examines the same export response to the US but against the China tariff. Here, the picture looks different: India's exports to the US decline with the China tariff. So, on net, it is not immediately obvious how the trade war would have affected India's exports to the US, something examined more formally below.

Panels C and D plot India's exports to China against the US and China tariffs, respectively. The panel reveals that India's export growth to China was flat or slightly negative during the trade war along both tariffs. This suggests that the trade war did not translate into export gains in China for India.

Panels E and F report India's exports to the rest of world against the US tariff and China tariff, respectively. There is a sharp rise in exports to RW with the US tariff, and differentially so relative to the pre-trade war period. This is suggestive evidence that India benefited from the US tariffs not only by increasing exports to the US (Panel A), but also by increasing exports globally (Panel E). Panel F, however, reveals no differential export growth against the China tariff to the rest of world. Together, the visual patterns suggest that India's exports to RW may have increased, and in the next subsection, I analyze this formally through the regressions specifications.

4.2. Main Results

I now examine the main specifications in Equation (1) and report the results in Table 2.[10]

Column 1 of Table 2 reports India's export response to the US against the four tariffs. The coefficient β_1^{US} reveals that India's exports to the US increased with the US tariffs on China at an elasticity of 0.73 (se 0.46). This indicates that Indian varieties are substitutes for Chinese varieties in the US. The coefficient on the China tariffs, β_2^{US}, is negative, indicating that India's exports to the

10. Table A.2 examines pre-existing trends formally by regressing pre-war tariff changes $\Delta \ln X^n_{\omega,t=1}$ tariff changes and sector fixed effects. These results suggest that pre-existing trends are not a major concern, but the main regressions in Equation (1) will nevertheless include a pre-existing trend control in all specifications.

US declined with China's tariffs on the US. This finding could capture a value chain mechanism. The China tariff reduced US exports to China. If those exports use Indian products as inputs, then India's exports to the US would decline as the US lost market access in China. Both point estimates, however, are somewhat noisy. The direct impact of the US tariff increase on India is captured by β_3^{US}. There is a large and negative elasticity of -4.20 (se 1.05), indicating that India's exports are quite negatively responsive to these direct tariffs. The last coefficient β_4^{US} captures India's export response to the US against the tariff reductions it received in China. This coefficient is positive, though not statistically significant, perhaps revealing re-allocation out of the US along this tariff (recall that $\Delta \ln T_{IN}^{CH} < 0$). In sum, the pattern of India's tariff elasticities to the US are nuanced: the US tariff raised Indian exports but the other three tariffs reduce its exports.

TABLE 2. Export Responses to Tariffs, Main Specifications

	(1)	*(2)*	*(3)*
	$\Delta \ln X_{\omega}^{US}$	$\Delta \ln X_{\omega}^{CH}$	$\Delta \ln X_{\omega}^{RW}$
$\Delta T_{CH,\omega}^{US}$ (β_1)	0.73 (0.46)	0.17 (0.79)	0.40 (0.31)
$\Delta T_{US,\omega}^{CH}$ (β_2)	-0.72 (0.40)	-0.05 (0.79)	0.16 (0.25)
$\Delta T_{IN,\omega}^{US}$ (β_3)	-4.20*** (1.05)	-4.88* (1.82)	1.02 (0.82)
$\Delta T_{IN,\omega}^{CH}$ (β_4)	1.52 (0.93)	0.07 (1.73)	0.58 (0.68)
Pre-Existing Trend Control	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
R^2	0.06	0.07	0.11
N	3,578	2,806	5,050

Source: Comtrade.
Notes: Table reports the coefficients from specification (1). Columns 1, 2, and 3 examines India's exports to US, China, and RW, respectively. The specifications include sector fixed effects and pre-existing trend control variable, $\Delta \ln X_{\omega,t-1}^{n}$
Significance: *10%, ** 5%, *** 1%.

Column 2 of Table 2 reports India's export response to China. The point estimates are noisier. In particular, we do not see a sharp response with China's tariffs on the US; if anything, β_2^{CH} is negative (and quite noisy) indicating complements with US varieties. Curiously, we also see that India's exports to China decline with ΔT_{IN}^{US}; this indicates that India was not able to re-allocate its exports out of the US and into China in these products. Surprisingly, the

coefficient β_4^{US} β_4^{US} is essentially zero and quite noisy, suggesting that the MFN tariff declines did raise India's exports to China, on average. But it is difficult to conclude much, given the large standard errors.

Column 3 of Table 2 reports India's export response to RW. The first two rows suggest that India's exports to RW increased with the US-China tariffs, but again the results are noisy. The positive coefficient in the third row suggests that India's exports to RW increased with the direct tariffs that the US imposed on India, which is consistent with an upward-sloping reallocation channel. But, as before, the standard errors on the tariffs responses are high, making it difficult to form sharp conclusions about India's exports to RW.

While examining the marginal response of exports to each of the four tariff changes is instructive, it masks the overall impacts of tariff changes on exports. As noted above, the US and China changed tariff rates on overlapping products, so to better understand India's export response to the trade war, I perform an exercise that aggregates exports to each destination across the tariff impacts. As discussed above, the procedure does not incorporate the impacts of the tariffs on destination-sector fixed effects α_j^n in (1). Thus, the aggregation procedure does not incorporate general equilibrium impacts of the tariffs that operate above the sector level. For example, if the tariffs affected exchange rates or wages at the national level, the aggregate response would not reflect this. See Fajgelbaum et al. (2021) for an extended discussion of this aggregation point.

To perform the aggregation, I first generate the predicted impacts of the tariffs at the product level using the coefficients from Table 2:

$$\Delta \widehat{\ln X_\omega^n} = \widehat{\beta_1^n}\,\Delta \ln T_{CH,\omega}^{US} + \widehat{\beta_2^n}\,\Delta \ln T_{US,\omega}^{CH} + \widehat{\beta_3^n}\,\Delta \ln T_{IN,\omega}^{US} + \widehat{\beta_4^n}\,\Delta \ln T_{IN,\omega}^{CH} \qquad (2)$$

Next, I aggregate these product-level exports to the destination by weighing each product by the (pre-war) export share to each destination:

$$\Delta \widehat{\ln X^n} = \lambda_\omega^n \Sigma_\omega \; \Delta \widehat{\ln X_\omega^n} \qquad (3)$$

where λ_ω^n is product ω's share of India's exports to each destination.

Finally, I further aggregate the export responses to the world by taking a weighted average of the (pre-war) export responses across the three destinations

$$\Delta \widehat{\ln X^{WD}} = \Sigma_{n=US,CH,RW} \Lambda^n \; \Delta \widehat{\ln X^n} \qquad (4)$$

where Λ^n is destination n's share of India's exports to the world.

The aggregation results are reported in Panel A of Table 3. Below the estimates are bootstrapped standard errors that are computed through the following procedure: 1) draw a sample, with replacement, of products within sectors; 2) estimate the specifications in (1); 3) construct the aggregate predicted exports to each destination using (2) and (3); and 4) repeat 100 times to compute the standard errors of the aggregate responses.

TABLE 3. India's Aggregate Response to Trade War

Panel A: All Tariffs			
US	*CH*	*RW*	*World*
-7.7	0.3	4.2	1.7
(6.0)	(12.1)	(4.4)	(3.6)
Panel B: US-China Tariffs Only			
US	*CH*	*RW*	*World*
-3.1	0.6	4.8	3.0
(5.5)	(12.1)	(4.2)	(3.4)

Source: Comtrade.

Notes: Table reports the coefficients from specification (1) and aggregated using the procedure described in (2)-(4). Panel A reports the response to all tariffs, and Panel B reports the response to the US-China bilateral tariffs only (i.e., setting $\beta_3^n = \beta_4^n = 0$ (1)). Bootstrapped standard errors reported in parentheses.

The results show that India's aggregate response to the US decreased 7.7 percent, but with a standard error of 6.0 percent around this estimate. Although India's exports to the US increase with the US tariff, its exports decline along the three other tariffs, as shown in Table 2. In aggregate, the tariffs have a negative impact on India's exports to the US, although there is considerable variance around that estimate.

India's aggregate response to China is muted and noisy. Exports increased by 0.3 percent with a standard error of 12.1 percent. The flat response is due to the relatively attenuated coefficients in column 2 of Table 2.

Finally, aggregate exports to RW increased by 4.2 percent (se 4.4 percent). It is a sizable response, but again is noisy. Through the lens of the model, this pattern of decreased exports to the US, flat response to China, and increased exports to RW suggests that India operates under textbook upward-sloping supply curves.

Aggregating across the response to the three destinations using Equation 4, the results indicate that the trade war increased India's global exports by 1.7 percent with a standard error of 3.6 percent. This leads to one main takeaway from the analysis: the trade war did little to stimulate aggregate exports for India. The bottom panel of Table 3 considers the impact of just the US-China bilateral tariffs on each other. The reason to focus on these two tariffs is to think about a counterfactual scenario where international market conditions just change indirectly for India, rather than also including the direct tariff changes on India. To do so, I construct the predicted responses by setting $\beta_3^n = \beta_4^n = 0$ in (2), re-perform the aggregation, and present the aggregate impacts in Panel B of Table 2. In the absence of negative impacts of the direct US tariff hikes on India, its exports the US would have been less negative. But, across destinations and on net to the world, focusing on the bilateral US-China tariffs does not

qualitatively change the message: exports to the world are predicted to increase by 3.0 percent (se 3.4%).

4.3. Heterogeneous Responses

In the framework, India's export response differs to each destination depending on demand and supply-side parameters. However, it imposes common elasticities across products to each destination. In this section, I relax this assumption by allowing the coefficients to vary by destination and sector/product characteristics.

4.3.1. By Sector

I re-estimate Equation (1) separately by destination and sector. With the products classified into the 9 sectors reported in Table 1, this yields 27 regressions (9 sectors to 3 destinations) with each regression estimating the four tariffs coefficients. Given the large number of results to interpret, I report the aggregate responses (full results are available upon request). Specifically, I estimate Equation (1) by destination-sector, and then perform the aggregation steps in Equations (2)–(4) to obtain the aggregate responses by sector. The results are reported across nine panels in Table 4. As before, the top row reports the impact of all four tariffs and the bottom reports the impact of just the US-China tariffs. The final panel, Panel J, aggregates the responses across all sectors using pre-war sectoral weights to obtain the overall impact of the tariffs on India's exports.

The main message of Table 4 is that the responses by sector are quite noisy. The two exceptions are the apparel and transport sectors, which account for 10.6 percent of India's exports in 899 products and 5.6 percent of India's exports in 130 products, respectively. In apparel, there is a strong response to China, and this drives an overall export expansion of apparel to the world. For transport, there are a particularly large response to US and RW and to the world. However, when aggregating across sector responses (Panel J), allowing for sectoral heterogeneity in the tariff responses does not qualitatively change the message from the baseline results: the trade war increased India's global exports by 6.0 percent (se 5.7 percent). Nor does the message change when the analysis only considers the US-China tariffs (the lower sub-panel in J: 6.5 percent with standard error of 5.6 percent).

TABLE 4. Aggregate Response, Heterogeneity

Panel A: Agriculture

US	*CH*	*RW*	*World*
-16.8	-9.1	11.9	6.8
(11.4)	(46.3)	(9.5)	(7.9)
-12.2	-7.2	11.2	7.1
(11.3)	(46.1)	(9.6)	(8.0)

Panel B: Apparel

US	*CH*	*RW*	*World*
13.5	48.1	18.8	19.2
(23.4)	(26.3)	(11.4)	(9.1)
-4.8	38.4	8.0	6.7
(14.1)	(25.4)	(7.3)	(5.8)

Panel C: Chemicals

US	*CH*	*RW*	*World*
-6.4	-18.5	-4.3	-5.6
(7.8)	(30.8)	(10.4)	(7.8)
0.2	-18.2	0.7	-0.3
(4.3)	(30.6)	(9.3)	(6.6)

Panel D: Machinery

US	*CH*	*RW*	*World*
-25.6	37.7	-4.5	-5.9
(19.2)	(26.2)	(13.1)	(11.0)
-26.3	35.8	-2.7	-4.6
(19.2)	(26.3)	(12.9)	(10.8)

Panel E: Materials

US	*CH*	*RW*	*World*
2.2	-13.9	-9.5	-7.1
(24.2)	(32.5)	(13.8)	(11.8)
8.9	-12.7	-5.5	-2.6
(21.7)	(33.2)	(12.2)	(10.6)

Panel F: Metals

US	*CH*	*RW*	*World*
11.3	-52.4	-11.9	-13.1
(18.8)	(40.6)	(13.9)	(12.1)
33.2	-51.2	-16.9	-14.4
(20.6)	(40.9)	(15.1)	(13.0)

Panel G: Minerals

US	*CH*	*RW*	*World*
-123.2	72.8	44.3	30.7
(92.6)	(56.5)	(48.2)	(40.5)
-126.1	72.1	46.8	32.3
(96.7)	(56.2)	(54.6)	(45.8)

Panel H: Miscellaneous

US	*CH*	*RW*	*World*
2.9	-13.6	-18.7	-12.6
(17.3)	(46.2)	(14.2)	(10.5)
6.0	-11.7	-12.1	-7.1
(17.4)	(46.4)	(14.7)	(10.9)

Panel I: Transport

US	*CH*	*RW*	*World*
119.8	39.5	53.7	60.8
(76.3)	(88.9)	(33.1)	(30.6)
111.8	53.5	61.2	66.6
(67.1)	(71.8)	(28.3)	(26.2)

Panel J: All Sectors

US	*CH*	*RW*	*World*
-8.3	9.1	7.3	6.0
(13.7)	(13.1)	(6.2)	(5.7)
-6.9	8.9	7.8	6.5
(13)	(12.8)	(6.2)	(5.6)

Source: Comtrade.

Notes: Table reports the aggregate responses of India's exports for different sets of products. Within each panel, the top rows report the response to all tariffs and the bottom rows report the response to the US-China bilateral tariffs only (i.e., setting $\beta_3^n = \beta_4^n = 0$ in (1)). Panel B estimates (1) on Agriculture, covering 10.6 percent of India's exports in 899 products. Panel B estimates (1) on Apparel, covering 15.2 percent of India's exports in 912 products. Panel C estimates (1) on Chemicals, covering 15.2 percent of India's exports in 787 products. Panel D estimates (1) on Machinery, covering 9.3 percent of India's exports in 771 products. Panel E estimates (1) on Materials, covering 22.0 percent of India's exports in 639 products. Panel F estimates (1) on Metals, covering 8.9 percent of India's exports in 563 products. Panel G estimates (1) on Minerals, covering 10.9 percent of India's exports in 148 products. Panel H estimates (1) on Miscellaneous, covering 2.3 percent of India's exports in 354 products. Panel I estimates (1) on Transport, covering 5.6 percent of India's exports in 130 products. Panel J estimates (1) aggregates across sectors. Bootstrapped standard errors reported in parentheses.

4.3.2. By Product Characteristics

While the previous specifications allow for different tariff responses across sectors, it is possible that export responses differ according to certain product characteristics. I consider heterogenous responses along four characteristics: product size, the strength of India's comparative advantage in the product, technological sophistication, and capital intensity. I also examine export responses based on measures that capture products' intensity in global value chains.

Panel A of Table 5 considers the aggregate response of the top 10th percentile products in terms of global exports. This panel covers 83.4 percent of India's exports in 521 products. As before, the message does not change. The tariffs increase global exports in these products, but the standard error is large.

An alternative dimension of heterogeneity is to examine India's exports of its highly comparative advantage products. Using pre-war flows, I construct products revealed comparative advantage as

$$\frac{X_{\omega}^{WD} \Big/ \Sigma_{\omega} X_{\omega}^{WD}}{\Sigma_{i} X_{i\omega}^{WD} \Big/ \Sigma_{i} \Sigma_{\omega} X_{i\omega}^{WD}}$$

where X_{ω}^{WD} denotes India's exports to the world in product ω, and $X_{i\omega}^{WD}$ denotes all other countries' exports of ω to the world. Panel B considers the response of top 10th percentile RCA products, which cover 41.8 percent of India's exports. Here, we do observe a large increase in exports to RW, and to the world overall, but somewhat noisy. This suggests that the trade war may have reinforced India's existing pattern of comparative advantage, but the evidence is not sharp.

Next, I examine the differential response in HS6 codes classified by the US as advanced technology products (ATP). In 1989, the US Census Bureau introduced the ATP classification to track trade in high-technology products (Ferrantino et al. 2007). For the US, one of the stated geopolitical goals of the trade war was to reduce its imports and exports of sensitive technology products with China. This could create an opportunity for India to increase exports of these products to the US. Prior to the trade war, ATP goods accounted for 9.1 percent of India's pre-war exports in 235 products. As shown in Panel C of Table 5, aggregate exports of ATP goods decreased by 6.9 percent (se 5.6%). This suggests that there is little evidence that the trade war led, at least thus far, to meaningful shifts in India's exports of advanced technology products.

Panel D examines the response of products in the top 10th percentile of capital intensity, as measured by Ma et al. (2014) from Chinese production data. These products cover 10.2 percent of India's exports. There is no clear pattern of response among these products.

Examining the responses of intermediate products is natural in an era of global value chains. I rely on the UN's Broad Economic Category classification that

TABLE 5. Aggregate Response, Product Heterogeneity

Panel A: Top 10th Pctile, Size			
US	*CH*	*RW*	*World*
10.8	0.6	-5.7	-2.2
(13.2)	(26.4)	(6.6)	(5.6)
2.4	-1.9	-4.7	-3.5
(11.0)	(26.1)	(5.0)	(4.4)

Panel B: Top 10th Pctile, RCA			
US	*CH*	*RW*	*World*
6.3	15.3	14.0	12.7
(15.8)	(20.4)	(12.2)	(10.0)
-1.9	10.7	10.2	7.7
(13.4)	(19.7)	(10.2)	(8.1)

Panel C: ATP Products			
US	*CH*	*RW*	*World*
-4.1	8.1	-7.6	-6.9
(5.7)	(13.7)	(6.8)	(5.6)
-2.7	7.3	-1.8	-1.8
(4.4)	(12.5)	(3.7)	(2.9)

Panel D: Capital Intensive			
US	*CH*	*RW*	*World*
0.6	-21.2	8.5	5.1
(23.2)	(31.0)	(12.9)	(10.5)
6.0	-13.1	8.4	6.4
(22.3)	(31.3)	(11.0)	(9.5)

Panel E: Intermediate			
US	*CH*	*RW*	*World*
4.0	2.5	0.7	1.4
(9.3)	(13.8)	(6.3)	(5.5)
3.8	5.5	1.9	2.2
(7.4)	(13.4)	(5.4)	(4.6)

Panel F: Contract Intensive			
US	*CH*	*RW*	*World*
-15.3	23.9	-5.8	-6.6
(11.8)	(19.6)	(7.6)	(6.2)
-9.4	23.9	3.1	1.2
(10.3)	(19.9)	(6.2)	(5.1)

Panel G: Upstream			
US	*CH*	*RW*	*World*
-7.1	-5.7	-17.8	-15.0
(16.1)	(31.2)	(20.0)	(15.3)
-1.9	-1.1	-1.7	-1.8
(13.8)	(30.4)	(16.7)	(13.2)

Panel H: Differentiated			
US	*CH*	*RW*	*World*
-10.4	-5.4	5.3	1.8
(7.2)	(13.9)	(4.7)	(3.9)
-5.0	-4.9	6.5	3.7
(6.8)	(13.5)	(4.5)	(3.8)

Source: Comtrade.

Notes: Table reports the aggregate responses of India's exports for different sets of products. Within each panel, the top row shows the baseline response and the bottom row shows the response to the US-China bilateral tariffs only (i.e., setting $\beta_3^n = \beta_4^n = 0$ in (1)). Panel A estimates (1) on the top 10th percentile products with largest export values to the world; this panel covers 83.4 percent of India's pre-war exports in 521 products. Panel B estimates (1) on the top 10th percentile products with largest RCA values; this panel covers 41.8 percent of India's exports. Panel C estimates (1) on advanced technology products (ATP); this panel covers 9.1 percent of India's exports in 235 products. Panel D estimates (1) on products with top 10th percentile capital intensity; this panel covers 10.2 percent of India's exports. Panel E estimates (1) on intermediate products as according to the UN Broad Economic Categories classification; this panel covers 69.8 percent of India's exports in 3,822 products. Panel F estimates (1) on products in the top 10th percentile of contract intensity, as defined by Nunn(2007); this panel covers 12.5 percent of India's exports. Panel G estimates (1) on products in the top 10th percentile of the upstream measures developed by Antràs et al. (2012); this panel covers 13.1 percent of India's exports. Panel H estimates (1) on differentiated products, as defined by Rauch (1999); this panel covers 79.4 percent of India's exports in 4,011 products. Bootstrapped standard errors reported in parentheses.

assigns an end-use to sectors which are then mapped to HS6 codes. According to this classification, intermediate goods accounted for 69.8 percent of India's

2017 exports in 3,822 products. Panel E reports the response of intermediate exports to the tariffs. As before, the estimates remain noisy.

An alternative way to understand exports within the value chain is to consider the response of products that rely more heavily on contracts. Antràs and Chor (2012) argue that trade within global value chains is of products that are highly customizable and governed by contracts that are incomplete and difficult to enforce. Thus, if India is to integrate further into GVCs, it is instructive to examine its response in products that are contract-intensive. Nunn (2007) develops a measure of contract intensity based on the extent to which a final product is produced through differentiated inputs. Panel F of Table 5 reports the response of products in the top 10th percentile of this contract intensity measure, covering 12.5 percent of India's pre-war exports. Again, there is no discernible impact of the tariffs on India's exports of these products.

A third way to analyze India's response within value chains is to look at products that are produced upstream. Antràs and Chor (2012) provide a measure of a sector's position in the supply chain using standard input-output matrixes, which can then be mapped to the HS6 classification. Panel G reports products with an upstream measure in the top 10th percentile, covering 13.1 percent of India's 2017 exports. As before, the results are noisy.

Finally, Panel H examines the export response in differentiated products, as defined by Rauch (1999), covering 79.4 percent of India's 2017 exports in 4,011 products. The message remains the same.

To conclude, aside from the apparel and transport sectors, Table 5 indicates no clear heterogenous response of India's exports to the trade war along the dimensions considered.

4.4. Product-Extensive Margin

The analysis has so far examined the trade war's impact along the product-intensive margin, i.e., India's exports of continuing products. It is also possible that the trade war affected entry into and/or exit out of products. The product-extensive margin response would not quantitatively affect aggregate impacts of the war since it accounts for 0.4 percent of India's export growth over this time period (with continuing products accounting for 99.6 percent of export growth). Of the 123 products that India could have entered in 2018–2019 (i.e., these are products that India did not export in 2016–2017), the country entered 41 HS codes. Moreover, India exited only 25 products in 2018–19 (i.e., these are products that India exported in 2016–17 but did not export in 2019–19). Thus, there is a small net entry into new products during this period. But while the product-extensive margin may be important over long intervals, it would not have been an important contributor to India's aggregate exports during this period.

4.5. Firm-Extensive Margin

Using Datamyne data, I can examine the firm-level response to the trade war tariffs. As discussed in Section 2.2, these results should be interpreted with some caution since they do not capture the universe of India's exports. Nevertheless, they can be used to understand the firm-level margins of adjustment to the tariffs.

To facilitate comparison with the product-level analysis, I perform a decomposition exercise that partitions export responses into the intensive and extensive margins. Consider the identity:

$$X_\omega \equiv \frac{X_\omega}{N_\omega} N_\omega \tag{5}$$

where X_ω is the total exports and N_ω is the number of exporters in product ω (at time t). Taking logs and first differencing over time, $\Delta \ln X_\omega \equiv \Delta \ln \frac{X_\omega}{N_\omega} + \Delta \ln N_\omega$. The term $\Delta \ln \frac{X_\omega}{N_\omega}$ reflects the growth in the average exports per firm, or the intensive margin. The term $\Delta \ln N_\omega$ captures growth in the number of exporters per product, or the extensive margin. I can re-run Equation (1) using these three terms as the outcome responses to learn the overall response to the tariffs (as was done with the Comtrade data), but now can determine how that response exactly decomposes into the two margins of adjustment.

Table A.3 reports the results of those regressions. If Datamyne data aggregated perfectly to Comtrade data, the coefficients in Panel A would be identical to Table 2.[11] Column 1 reports the results for exports to the US. Compared to Column 1 of Table 2, the coefficients are fairly similar, with the exception of the coefficient on China's tariff reductions, ΔT_{IN}^{CH}, which is negative here but positive in Table 2. There are more discrepancies between the results for China and RW between Datamyne and Comtrade data. One potential source of the difference lies with the discrepancy in the number of products exported to the two destinations; the Comtrade data report India exporting more products to China and RW than Datamyne data.[12] The second source of difference lies in potentially more measurement error in Datamyne data, also discussed in Section 2.2. Since product-level exports exactly decompose into the intensive and extensive margins according to (5), the coefficients on each tariff in Panel B

11. The point estimates would be identical leaving aside the control for pre-existing trends, which are not included in the decomposition regressions.

12. As noted in Section 2.2, I define India's exports through the countries' reported imports from India, but use India's exports in Datamyne data. This difference could also explain the discrepancy in the number of products exported to China between the two data sets. For example, Indian firms may use Hong Kong as a trans-shipment point and label the destination to Hong Kong, while Comtrade imports records may appropriately classify these such transactions as sales in China.

(the intensive margin response) and Panel C (the extensive margin response) will sum exactly to the coefficients in Panel A. For example, product-level exports to the US respond to the US tariff, $\Delta T^{US}_{CH,\omega}$, with an elasticity of 1.57 (Panel A, column 1, row 1). This response decomposes exactly into an intensive margin response of 1.02 (Panel B, column 1, row 1) and extensive margin response of 0.56 (Panel C, column 1, row 1). Likewise, exports to the RW respond to the CH tariff, $\Delta T^{CH}_{US,\omega}$, with an elasticity of 0.41 (Panel A, column 3, row 2) which decomposes into an intensive margin response of 0.12 (Panel B, column 3, row 2) and 0.29 (Panel C, column 3, row 2).

As before, it is useful to aggregate the regressions using the procedure in Equations (2)-(4) to assess overall impacts. The decomposition properties are preserved, so this procedure can decompose the aggregate response to the tariffs into both margins. The first row of Panel A of Table A.4 shows the overall response, which again, if Datamyne data perfectly matched the Comtrade data, would be identical to Panel A in Table 3. Although the numbers do not match, the impacts are noisy and the two tables do align within margins of error. Moreover, Datamyne data confirm the noisy aggregate response of Indian exports to the trade war. The second and third rows report how the overall export response decomposes into the two margins. The final row reports the contribution of the extensive margin as a percent of the overall response. As before, the bottom panel of this table reports the impact of just the bilateral US-China tariffs.

There are two messages from Table A.4. First, the contribution of the extensive margin into US and China is roughly 40 percent. This means that for every five percentage points increase in growth to these two markets caused by the tariffs, two percentage points is driven by firms entering product lines that they had not previously exported. Second, the contribution of the extensive margin to the RW response is even larger; the tariffs lower exports along the intensive margin but causes entry into these product lines. The result is a sizable response of the extensive margin.

With the data caveats in mind, this table provides some optimism around India's overall lackluster export response. It suggests that the tariffs cause exporters to expand their export scope by entering new product lines.

5. Conclusion

The recent shocks to the world trade system—Brexit, the US-China trade war, the COVID-19 pandemic, the Russia-Ukraine conflict, and increased nationalism in the West and China—have ushered in an era of heightened geopolitical tensions. Of course, these events directly affect trade and investment of the involved countries. But bystander countries are also affected and may stand to gain.

This paper offers an analysis of India's export response to the US-China trade war from 2018–19. I find that the trade war raised India's exports by 1.7 percent but with considerable error around this estimate. I conclude that the export response was not sharp, nor do I find sharp patterns across a range of sector and product characteristics. There is some evidence that the tariffs increased firm entry into products, particularly for exports to the rest of the world, which offers some optimism that the trade war has created an opportunity for India to broaden its export base over the long-run.

The lackluster export response begs more questions than can be answered from these administrative data. The framework developed in Fajgelbaum et al. (2021) points to two broad determinants of the export response to the tariffs: How substitutable are firms' products relative to the targeted country? And, how strong are the reallocation frictions and scale for production? Tailored surveys that collect information on exporters' product quality, searching and matching frictions for overseas buyers, production structures, and constraints on factor markets can open the black box to reveal the binding constraints that Indian firms face in global markets.

As an example, an emergent literature has documented that a particular form of non-trade barriers—information frictions—can have consequential impacts on trade.[13] Were Indian firms aware of the magnitude of tariff changes in the precise product codes they export? Were they aware of how their competitors were responding? Could they find buyers in China or the US, and if so, through what platforms? Was trade financing difficult to secure? Did the products they export appeal to US and/or Chinese consumers? Given the challenges of contracting on specialized products, how easy is it for Indian businesses to build trust with buyers so that relational contracts emerge?[14]

The data used in this paper are not detailed enough to answer these questions. As such, a final contribution of this paper is to urge policymakers to create tailored surveys and launch targeted interventions to understand fully the challenges that Indian exporters face in global markets.

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13. Atkin et al. (2017) conduct a randomized trial that lowers search and matching frictions for Egyptian rug producers to find overseas buyers, and document large impacts on profits, quality and productivity. For a review of the literature on information frictions and trade, see Atkin and Khandelwal (2020).

14. Banerjee and Duflo (2007) provide an analysis of the importance of reputation and contracting for Indian software exports in the late 1990s. Macchiavello (2022) provides an excellent review of the importance of relational contracts in developing countries.

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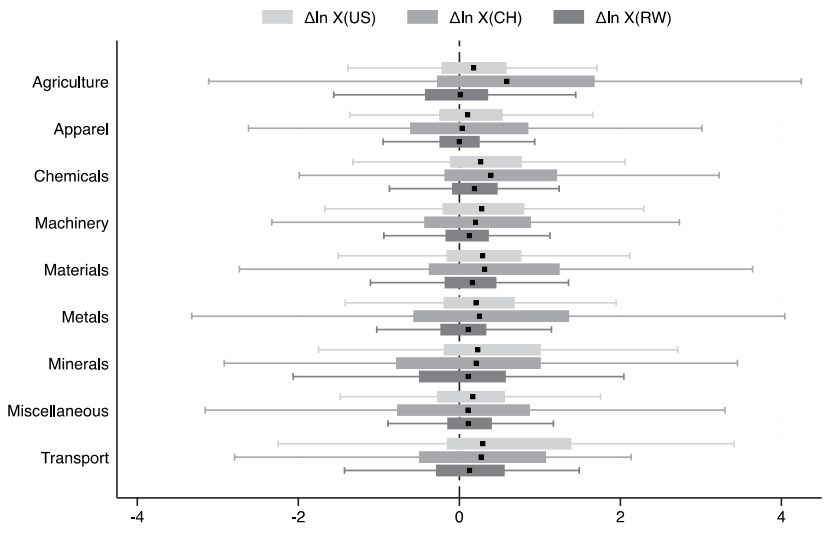
Appendix Tables and Figures

FIGURE A.1. Raw Export Changes



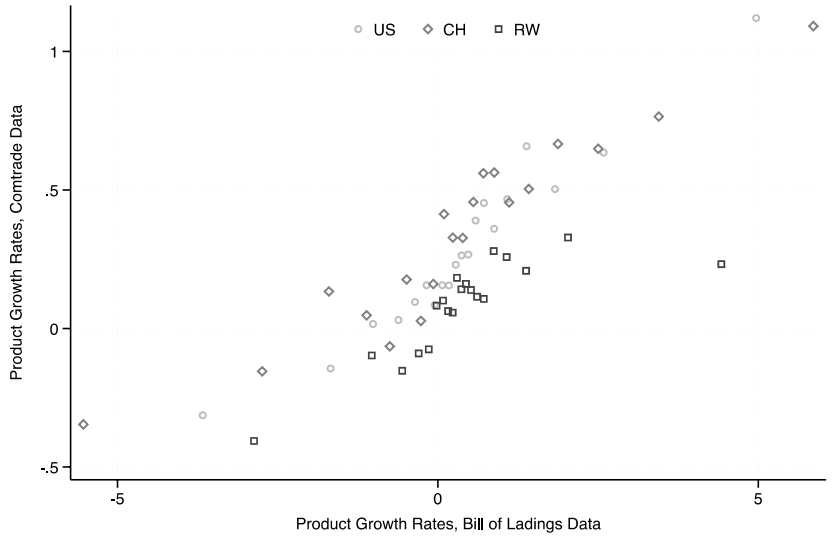
Source: Fajgelbaum et al. (2021).
Notes: This figure reports product-level growth rates by destination and sector. The black dots indicate the median tariff increase, the boxes denote the 25th and 75th percentiles, and whiskers show the 10th and 90th percentiles.

TABLE A.1. Comparing Comtrade with Datamyne

Panel A: Comtrade Data		
	2017	2019
Exports to US	46	54
Exports to CH	12	17
Exports to RW	236	252
Exports to World	294	323
Panel B: Datamyne Data		
	2017	2019
Exports to US	32	42
Exports to CH	9	15
Exports to RW	171	225
Exports to World	212	283

Source: Comtrade and Datamyne.
Notes: Table compares aggregate export values in Comtrade and Datamyne data for 2017 and 2019. All values in USD billions.

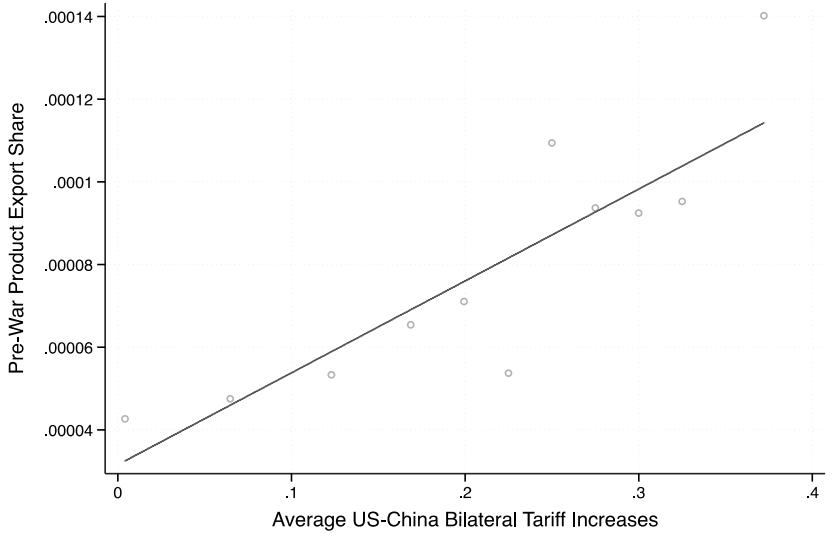
FIGURE A.2. Product-level Growth Rates in Comtrade versus Datamyne Data



Source: Comtrade and Datamyne.

Notes: Figure reports a binscatter of product-level global export growth in Comtrade versus Datamyne data. The Comtrade growth rates are from 2016–17 to 2018–19, and Datamyne growth rates are computed from 2017 to 2019.

FIGURE A.3. Average US-China Bilateral Tariff Changes and Export Shares



Source: Comtrade.

Notes: Figure reports a binscatter of India's product-level global export shares against the product-level average $\Delta T^{US}_{CH,\omega}$ and $\Delta T^{CH}_{US,\omega}$. The figure removes India's top 2 percent products before constructing the binscatter because those shares are significantly larger than the remaining 98 percent of products.

TABLE A.2. Checks for Pre-existing Trends

	(1)	*(2)*	*(3)*
	$\Delta X^{US}_{\omega,t-1}$	$\Delta X^{CH}_{\omega,t-1}$	$\Delta X^{RW}_{\omega,t-1}$
$\Delta T^{US}_{CH,\omega}(\beta_1)$	-0.14	-0.22	-0.33
	(0.48)	(0.85)	(0.32)
$\Delta T^{CH}_{US,\omega}(\beta_2)$	0.14	0.30	0.66**
	(0.42)	(0.83)	(0.26)
$\Delta T^{US}_{IN,\omega}(\beta_3)$	-1.26	5.16**	-0.77
	(1.10)	(1.95)	(0.85)
$\Delta T^{CH}_{IN,\omega}(\beta_4)$	-2.48*	-1.12	0.27
	(0.97)	(1.80)	(0.71)
Sector FE	Yes	Yes	Yes
R^2	.01	.009	.0023
N	3,530	2,714	5,054

Source: Comtrade.

Notes: Table reports the coefficients from specification (1), using $\Delta \ln X^{n}_{\omega,t-1}$ as the dependent variable. Columns 1, 2, and 3 examine India's exports to US, China, and RW, respectively. The specifications include sector fixed effects. Significance: * 10%, ** 5%, *** 1%.

TABLE A.3. Export Responses to Tariffs, Decomposition

Panel A: Overall Response			
	$\Delta \ln X^{US}_{\omega}$	$\Delta \ln X^{CH}_{\omega}$	$\Delta \ln X^{RW}_{\omega}$
	(1)	*(2)*	*(3)*
$\Delta T^{US}_{CH,\omega}(\beta_1)$	1.57*	1.22	-0.29
	(0.75)	(1.23)	(0.46)
$\Delta T^{CH}_{US,\omega}(\beta_2)$	-0.63	0.93	0.41
	(0.65)	(1.17)	(0.38)
$\Delta T^{US}_{IN,\omega}(\beta_3)$	-5.03**	-5.86	1.13
	(1.87)	(3.01)	(1.19)
$\Delta T^{CH}_{IN,\omega}(\beta_4)$	-1.19	-4.94	2.33*
	(1.59)	(2.77)	(1.02)
Sector FE	Yes	Yes	Yes
R^2	0.01	0.01	0.01
N	3,598	2,265	4,760

(Table A.3. continued)

(Table A.3. continued)

Panel B: Intensive Margin

	$\Delta \ln(X/N)_{\omega}^{US}$	$\Delta \ln(X/N)_{\omega}^{CH}$	$\Delta \ln(X/N)_{\omega}^{RW}$
	(1)	*(2)*	*(3)*
$\Delta T_{CH,\omega}^{US}(\beta_1)$	1.02	0.70	-0.60
	(0.70)	(1.13)	(0.42)
$\Delta T_{US,\omega}^{CH}(\beta_2)$	-0.44	0.59	0.12
	(0.60)	(1.07)	(0.34)
$\Delta T_{IN,\omega}^{US}(\beta_3)$	-5.22**	-4.67	1.25
	(1.73)	(2.76)	(1.09)
$\Delta T_{IN,\omega}^{CH}(\beta_4)$	-1.25	-4.16	0.20
	(1.47)	(2.54)	(0.93)
Sector FE	Yes	Yes	Yes
R^2	0.01	0.01	0.01
N	3,598	2,265	4,760

Panel C: Extensive Margin

	$\Delta \ln N_{\omega}^{US}$	$\Delta \ln N_{\omega}^{CH}$	$\Delta \ln N_{\omega}^{RW}$
	(1)	*(2)*	*(3)*
$\Delta T_{CH,\omega}^{US}(\beta_1)$	0.56**	0.52	0.31*
	(0.20)	(0.31)	(0.15)
$\Delta T_{US,\omega}^{CH}(\beta_2)$	-0.19	0.34	0.29*
	(0.17)	(0.29)	(0.12)
$\Delta T_{IN,\omega}^{US}(\beta_3)$	0.19	-1.19	-0.12
	(0.51)	(0.75)	(0.38)
$\Delta T_{IN,\omega}^{CH}(\beta_4)$	0.06	-0.79	2.12***
	(0.43)	(0.69)	(0.32)
Sector FE	Yes	Yes	Yes
R^2	0.02	0.02	0.06
N	3,598	2,265	4,760

Source: Comtrade.

Notes: Table reports the coefficients from specification (1) on overall exports (Panel A), and the intensive (Panel B) and extensive margins (Panel C). Columns 1, 2 and 3 examine India's exports to US, China, and RW, respectively. The coefficients in Panel A exactly decompose into their corresponding coefficients in Panels B and C, as shown in (5). Significance: * 10%, ** 5%, *** 1%.

TABLE A.4. Aggregate Responses, Decomposition

Panel A: All Tariffs			
US	*CH*	*RW*	*World*
	Overall		
5.7	22.7	-1.2	0.7
(9.6)	(17.3)	(6.5)	(5.7)
	Intensive Margin		
3.4	14.2	-3.2	-1.5
(8.5)	(15.6)	(6.1)	(5.3)
	Extensive Margin		
2.3	8.5	1.9	2.2
(2.7)	(4.3)	(2.1)	(1.8)
	Extensive Margin Contribution		
40.6%	37.5%	156.7%	319.3%
Panel B: US-China Tariffs Only			
US	*CH*	*RW*	*World*
	Overall		
5.6	20.3	2.0	3.2
(8.6)	(16.9)	(5.8)	(5.1)
	Intensive Margin		
3.3	12.2	-3.4	-1.8
(7.6)	(15.2)	(5.6)	(4.8)
	Extensive Margin		
2.3	8.2	5.4	5.0
(2.4)	(4.2)	(1.9)	(1.6)
	Extensive Margin Contribution		
41.4%	40.1%	265.9%	157.4%

Source: Datamyne.

Notes: Table reports the coefficients from specification (1) and aggregated using the procedure described in (2)–(4) on Datamyne data. Panel A reports the response to all tariffs, and Panel B reports the response to the US-China bilateral tariffs only (i.e., setting $\beta_3^n = \beta_4^n = 0$ in (1)). Within each panel, the first subpanel reports the overall response, and the second and third subpanels report the contribution of the intensive and extensive margins, as defined in (5). The final row reports the contribution of the extensive margin. Bootstrapped standard errors reported in parentheses.

To view the entire video of this IPF session and the General Discussion that ended the session, please scan this QR code or use the following URL
https://youtu.be/Y-ZfhyStWoA

Comments and Discussion*

Chair: **B.V.R. Subrahmanyam**
Ministry of Commerce and Industry

Kenneth M. Kletzer
University of California, Santa Cruz

This paper was a pleasure to read. It is an exceptionally clear, informative, and thorough paper on an important subject for India. The interpretations and conclusions are all carefully drawn from the empirical results. The author provides an excellent analysis of the impact of the US-China tariff war on India's export performance. It follows up recent research by the author and his co-authors on the global re-allocation of exports during the trade war using cross-country data (Fajgelbaum et al. 2021). The framework for this paper is adopted from that paper. The results from the cross-country study also provide the context for assessing India's export response to the tariffs. I am going to use some of my comments to compare these results.

I begin by summarizing the empirical approach of the paper. The model estimates the simultaneous effects of the tariff increases on India's exports to the US, China, and the rest of the world separately. The flexibility of the model's specification suits its task well. On the demand side, translog preferences allow the semi-elasticity of demand for exports, for example to the US, to differ by their country of origin. Products can be either complements or substitutes for exports from China to the US, and supply curves may slope upward or downward. The underlying general equilibrium framework is used to derive the estimating equation in the paper. Semi-elasticities of Indian exports to the US, China, and rest of the world with respect to the US and Chinese tariff changes are estimated with fixed effects controlling for shifters of supply and demand.

As the paper notes, controlling for changes to the intercepts in export demands induced by the tariffs for each sector raises a caveat for interpreting the results. A portion of the effects of tariffs changes on exports is likely to be missed. The imposition of these fixed effects comes from the identification strategy. It assumes that export growth for each product within a sector would be the same over the period 2017-19 in the absence of the US-China trade war. Thus, the

* To preserve the sense of the discussions at the India Policy Forum, these discussants' comments reflect the views expressed at the IPF and do not necessarily take into account revisions to the conference version of the paper in response to these and other comments in preparing the final, revised version published in this volume. The original conference version of the paper is available on NCAER's website at the links provided at the end of this section.

variation in the growth of exports across products within a sector is attributed just to variation in the tariff increases on each product. Table A.2 in the paper reports checks for whether pre-existing trends in exports are affected by the future tariff changes, and controls for pre-existing export trends are included in nearly all the regressions. The identification strategy makes sense, but the paper devotes just a single sentence to it. There is a clear succinct description in Fajgelbaum et al. (2021). I suggest incorporating a fuller explanation in this paper for the sake of clarity.

The results are interesting even though, as the author emphasizes, they are noisy. The partial effect of US tariffs on China is to raise Indian exports to the US. We see the same effects in the pooled results for all the bystander countries in the cross-country data. The point estimate for the semi-elasticity of exports to the US with respect to China's tariffs on US products is negative and larger than for the pooled global regression. The plausible (and given) interpretation is that India's exports to the US provide inputs to US products exported to China, suggesting the possible importance of the integration of India into US value chains. The main results are very much in line with the overall pooled results for all bystanders to the US-China trade war. The text points out a difference for the semi-elasticities for Indian exports with respect to the Most-Favored Nation (MFN) duty reductions by China. I noticed that the point estimates, though still insignificant, were of the expected sign from the individual regression for India in the cross-country analysis using somewhat different data.

An important aspect of the rise in protection by the US was the increase in tariffs on Indian steel and aluminum products and the termination of Indian benefits under the Generalized System of Preferences. As the paper points out, India was unable to re-allocate exports of these products from the US to China. Thus, the overall impact of the tariff war on India's exports to the US was negative. The estimated semi-elasticity is negative and significant, while the rise in exports of these products to the rest of the world is positive but insignificant. This was not a unique experience: the pooled regression from the global re-allocation paper gives a negative semi-elasticity for all bystander exports to China with respect to tariffs imposed on their products by the US. The US tariff increases for products from Malaysia and Vietnam reduced those countries' exports to China, and the elasticities are comparable to those for Indian exports (Fajgelbaum et al. 2021, Table A3). The reduction in exports of products targeted by US tariff increases to China is more puzzling because it is shared by countries that appear to be better able to find substitute markets for the US than India.

The examination of possible sources of the heterogeneous responses across products provides a couple of findings, but mostly an absence of results. It is interesting that comparative advantage does not help explain the pattern of export intensification to the US. The cross-country study also shows that the heterogeneity of the response of exports to the tariffs is not explained by

variations in the products exported by countries. Further, none of the other measures used to capture product intensity in global value chains helps explain the variation in exports for India. The empirical results tell us to look beyond product characteristics for understanding the export response.

The firm-level data yield interesting results for the decomposition of the export changes between the extensive and intensive margins. The paper finds that the entry by firms into new export markets is an important share of export expansion by India. The increases in exports at the extensive margin to the US and to the rest of the world in response to the US tariffs on China are both significant. So is entry to exporting to the rest of the world in response to China's tariffs on the US. I agree that the share of the extensive margin in India's export response to the trade war is an optimistic sign for India's ability to take advantage of trade opportunities.

I really appreciate the author's emphasis on the estimates for India being noisy. I want to point out that standard errors are similarly large for the individual country regressions in the cross-country study. The predicted changes in exports to the world for a majority of the 48 countries in the sample are also insignificant. However, the estimates for India's export increases are modest and compare unfavorably to the significant proportionate increases for several middle-income emerging market economies. Despite the inclusion of India as a target of US protectionism, the sluggish response of India's exports to all markets is an important policy question. Perhaps, the inadequacy of domestic infrastructure supporting foreign trade comes to mind first. Allow me, instead, to focus my remaining comments on next steps for understanding other barriers to export expansion.

The empirical analysis shows that we need to look beyond comparative advantage and other product characteristics for explanations of the heterogeneous responses across sectors and products to tariff changes. Possible explanations may be found in the access to credit, information, and trade relationships of incumbent and potential entrant firms to exporting, as well as in product quality or attributes. The author concludes his paper by posing several good questions for further research, highlighting information frictions.

The role of credit access for trade may be particularly important for India. As mentioned in an earlier IPF session where the paper on bank privatization was presented, domestic credit to the private sector from the banks accounts for 47 percent of GDP for India. For China, the ratio exceeds 180 percent and averages about 125 percent for the successful exporting Southeast Asian countries.

Financial frictions impede investment, innovation, and export participation. The extent to which financial frictions affect productivity, hence comparative advantage, is accounted for in the paper's analysis of heterogeneous effects across products. Other effects are not. The availability of trade credit can directly influence the response of exports across products and firms to changing opportunities for trade. The activities necessary for firms to be successful

entering or expanding in foreign markets are costly. These include acquiring information about foreign markets, matching products to foreign preferences, integrating into distribution networks and supply chains, and gaining market awareness. These all matter in themselves, but such expenditures require financing, either internal or external, to the firm. Credit access and the cost of credit probably interact with informational and relational frictions in trade.

In recent years, many papers have examined the causal relationship between financial frictions and firm-level export performance. Among mixed results, this research finds that the effects of credit market imperfections on firm-level exports are heterogeneous and vary with firm size, in particular. The effects tend to be significant for small and medium-sized firms. Given the magnitude and variety of imperfections in India's financial markets, combining trade and external financing data at the firm-level could be well worth the effort. Survey data collected for a set of firms could be matched with the trade data, as has been done for China. For example, rationing of export credit and export performance during the trade war might be a place to start. The potential impact of credit access on exports goes beyond access to trade credits. General access to external finance can also matter for export growth and vary widely across firms and industries.

The modest increase in exporting by India during the trade war could be a consequence of India's financial market barriers, or other inefficiencies for expanding exports. Looking to firm financing and trade credit to explain and improve export performance might be promising. This goes beyond the scope of the present paper, but I think it is the natural next step. In closing, this is an excellent and engaging paper on an important current policy issue facing India.

Reference

Fajgelbaum, P., P.K. Goldberg, P.J. Kennedy, A.K. Khandelwal, and D. Taglioni. 2021. "The US-China Trade War and Global Reallocations," *Working Paper No. 29562*. Cambridge, Massachusetts: National Bureau of Economic Research.

Prachi Mishra

IMF

The paper has tried to address the question as to whether India really capitalized on the US-China trade war, to which the short answer was 'not really'. The prediction made by *Financial Times* and several other newspapers was that India could benefit from the trade war but this prediction did not materialize in reality.

Data and Methodology

The paper is an adaption of the author's earlier co-authored paper (Fajgelbaum et. al. 2021), with the sample period of 2014-15 t0 2018-19. The estimating equation used in it is as follows:

$$\Delta \ln X_{\omega}^{n} = \alpha_{j}^{n} + \beta_{1}^{n} \Delta \ln T_{CH,\omega}^{US} + \beta_{2}^{n} \Delta \ln T_{US,\omega}^{CH} + \beta_{3}^{n} \Delta \ln T_{IN,\omega}^{US} + \beta_{4}^{n} \Delta \ln T_{IN,\omega}^{CH} + \varepsilon_{\omega}^{n}$$

In this paper, new data has been taken from UN Comtrade whereas the earlier paper used data from the International Trade Corporation. This paper also uses annual bilateral exports data at the HS6 level as opposed to monthly data in the erstwhile paper.

In this context, following are the four main changes suggested for the paper: (i) Incorporating full-blown heterogeneous country-specific responses from the Fajgelbaum et al. (2021) paper; (ii) Explaining the cross-country differences and exploiting the firm-level variation more; (iii) Excluding the US in bilateral tariffs to focus more on the re-allocation effects of the US-China War; and (iv) Considering a longer time dimension than the export growth between 2016-17 and 2018-19.

These suggestions are elaborated as follows. First, the heterogeneous responses across countries are very noisy. The standard errors are pretty high. Thus, one solution for this would be to just incorporate all the heterogeneous responses from the earlier paper (Fajgelbaum et al. 2021) and make a full-blown comparison between India and its peers. Another solution would be to bring in a deeper analysis using firm-level customs data. Some of the results were downplayed in the paper, for example, highlighting the results when the US imposed tariffs on China in terms of what happened on the extensive margin versus the intensive margin. These responses were both economically and statistically significant.

Second, for greater exploitation of firm-level variation and explanation of the cross-country differences, it is important to identify the sectors and firms that are actually taking advantage of the trade war, whether they are large or small firms, and whether they are more or less integrated with the value chains.

Third, the authors could consider excluding US in bilateral tariffs and focusing instead on the re-allocation effects of the US-China War, excluding elasticities that are high in magnitude. It makes little sense to aggregate a lot of effects, for example, on the policy side, including the direct bilateral tariffs imposed by the US on India, and by China on India, and removal of GSP, especially in the context of the current border issues playing out between India and China. The focus should instead be more on some of the re-allocation effects (Table 2 in the paper).

TABLE 2. Export Response to Tariffs, Main Specifications

	(1)	*(2)*	*(3)*
	$\Delta \ln X_{\omega}^{US}$	$\Delta \ln X_{\omega}^{CH}$	$\Delta \ln X_{\omega}^{RW}$
$\Delta T_{CH,\omega}^{US}(\beta_1)$	0.73	0.17	0.40
	(0.46)	(0.79)	(0.31)
$\Delta T_{US,\omega}^{CH}(\beta_2)$	-0.72	-0.05	0.16
	(0.40)	(0.79)	(0.25)
$\Delta T_{IN,\omega}^{US}(\beta_3)$	-4.20***	-4.88*	1.02
	(1.05)	(1.82)	(0.82)
$\Delta T_{IN,\omega}^{CH}(\beta_4)$	1.52	0.07	0.58
	(0.93)	(1.73)	(0.68)
Pre-Existing Trend Control	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
R^2	0.06	0.07	0.11
N	3,578	2,806	5,050

Notes: Table reports the coefficients from specification (1). Columns 1, 2, and 3 examines India's exports to US, China, and RW, respectively. The specifications include sector fixed effects and pre-existing trend control variable, $\Delta \ln X_{\omega,t-1}^{n}$. Significance: * 10%, ** 5%, *** 1%.

The fourth suggestion pertains to the time dimension. It was perceived that the Russia-Ukraine war would actually give a big boost to wheat exports from India, which did not happen in reality. It is imperative to specify that in any trading relationship, the time factor and issues of trust and reputation are hugely important. The period between 2016-17 and 2018-19 might be too short a time frame for some of the effects pertaining to export growth to show. It is recommended that this time period may be extended by at least a year and the results analyzed to arrive at more incisive conclusions and answer some of the key questions, such as how far the larger effects of the trade war would sustain in the countries in which they were observed.

Another suggestion on aggregation is the need for analyzing case studies and stories which show that there has been an increase of almost $40-50 billion in the exports of pharmaceuticals and chemicals during a very short time period. In the case of electronics, 30 firms are engaged in the handset assembly business whereas only 10 of them are actually using the Production-Linked Incentive (PLI) scheme. It would be insightful for the paper to study what the other firms are doing to augment their exports. The exports of textiles and apparel, particularly yarns and fabric, have also picked up quite significantly post the US-China Trade War. There is anecdotal evidence, as mentioned in the

paper, of exploding orders on other items too beyond yarns and fabric. These developments should be highlighted in the paper because it is imperative to identify the firms, products, or trading partners by collaborating with which India can actually take advantage in terms of boosting its exports.

The conclusions in the paper were a bit too strong relative to the analysis presented in it. It is recommended that the author could focus more on the magnitudes rather than exclusively on the noise, and consider country-specific heterogeneous responses from the Fajgelbaum et al. paper of 2021, while assessing the magnitudes of the differential effects and methodological or data deficiencies.

General Discussion

Commencing the discussion, the Chair, B.V.R. Subrahmanyam complimented the author of the paper for bringing a different perspective to the subject, trying to take it down to the firm level, and actually assessing the real challenges so that the solutions can be implemented into policy.

Surjit Bhalla offered suggestions on what could be done next. He said that 2010-11 and 2018-19 were periods of zero-world growth in exports, and very different than the erstwhile time period of 2000-2010. Second, in 2010, China moved up the value chain and there was a lot of discussion in India as to whether the country would be able to piggyback on that and expand its trade, but India did not benefit at all. And the usual suspects, Vietnam and Bangladesh benefited to a large extent. So, things did not improve for most countries during the period 2010-2019, given that the world trade itself was flat. The preliminary results for 2021 over 2019-20 suggest that India seems to have done spectacularly well in manufacturing exports. The rate of increase of India's manufactured exports was second only to Argentina during this period. Hence, this analysis may suggest that the two years that have just gone by may signify the advent of structural change in exports.

Pravin Krishna appreciated the discussion on substitutability and complementarity. He wondered that in terms of the actual estimation exercise, with complementarities that run across product lines, how one would get to what's happening to the demand for buttons if the tariff is on textiles or something like that? The same issue applies for intermediate inputs. He asked that if we do not have the benefit of a full input-output structure, is that a worry? Is that something that the estimation framework is taking care of?

Karthik Muralidharan flagged the author's initial comment that this is one of the biggest price changes that has been seen relative to even the Smoot-Hawley Tariff Act. But if despite that, all these estimates are noisy, does that suggest that we would never have the power to meaningfully pick up the differences

in this kind of approach? It is possible that this was a valiant attempt, but it's fundamentally underpowered to get at that question.

The second question concerns a different point than the focus of this paper, which was on role of the Generalized System of Preferences (GSP) and the direct impact of the U.S.-China trade war on India. Sajjid Chinoy, who is a member of the Economic Advisory Council to the Prime Minister (EAC-PM), has done extensive work in this area, showing that by far the most important predictor of exports is still the real exchange rate. And the period of flattening exports discussed in the paper is also a period of considerable strengthening of the rupee. Hence, today India is facing some political headwinds arguing against depreciation of the rupee vis-à-vis the dollar, but the trade-weighted exchange rate is still pretty flat. Politically, therefore, it is very difficult to allow the slide.

Responding to the comments, Amit Khandelwal asserted that his motivation was actually not to innovate on the existing paper to produce a policy-oriented paper, as the right model may not be to propose something new, which would be open to potential critiques. He wanted to focus on issues pertinent to India that have been discussed in other settings.

He averred that despite the standard noise in trade data, no sharp responses are seen to the tariffs of U.S.-China trade. They decline with each other, and some countries do benefit due to that. However, what the paper does not really answer is when we are powered and when we are not. One should think about this aspect of India's response in absolute terms, not whether it is better or worse or different from Cambodia.

Issues of credit are hugely important and many of the softer issues of information frictions are all part of the story. While some countries have resolved these frictions, to some extent, others have not, and that is where the attention should lie. As regards timing, he agreed that it is too short a time horizon, and currently, there is a lot more work showing that trading relationships rely extensively on relational contracting and relational contracting takes time to build, which is why two years may not be a sufficient enough time. Also, the analysis was stopped at the end of 2019, in part because the pandemic swamped everything.

As regards the rupee depreciation, the big question concerns the pass-through of the exchange rates. Most of India's exports would be invoiced in U.S. dollars. Since India does not invoice in local currency, that would limit the pass-through of depreciation. The question, therefore, is: To what extent does India benefit as a result of that?

B.V.R. Subrahmanyam rounded up the discussion by arguing that conducting interviews remotely in the export sphere is difficult, but forums like the Federation of Indian Chambers of Commerce and Industry (FICCI) and the Confederation of Indian Industry (CII) may not be the right places to go to. Instead, one should approach the 28 specialized export councils and sector

councils, as well as the Federation of Indian Export Organizations. Exports in India present an interesting picture. All the Indian Fortune 100 companies are domestic-oriented. Exports take place at one level below, and these agencies and individuals actually do not have a voice in Delhi. That is probably one of the reasons why exports have been ignored in the past.

Lastly, the tinkering on tariffs actually does not happen through the Directorate General of Foreign Trade (DGFT) but through the Revenue and Customs Departments. Although over the last 30 years, industry stopped approaching the Centre for support, it has started again with all industries now lobbying to push up their tariffs a little bit, which is not a positive sign.

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BESART AVDIU[*]
World Bank

KARAN SINGH BAGAVATHINATHAN[†]
University of Göttingen and German Development Institute

RITAM CHAUREY[‡]
Johns Hopkins University

GAURAV NAYYAR[#]
World Bank

India's Services Sector Growth: The Impact of Services Trade on Non-tradable Services[§]

ABSTRACT This paper examines the effect of tradable services growth on non-tradable services across Indian districts. We use a shift-share "Bartik-type" instrumental variable, that relies on changes in foreign demand shocks for tradable services, weighted by the initial district employment shares in tradable services. Using multiple rounds of the Indian Economic Censuses, we find that an increase in tradable services employment leads to an increase in non-tradable services employment and increases the number of firms in non-tradable services. Our evidence suggests that this positive impact is due to an increase in consumer demand for local non-tradable services that results from the growth in tradable services employment, and not due to sectoral linkages between tradable and non-tradable services sectors. The employment impact is much larger for female workers compared to male workers, and for the number of female-owned firms relative to male-owned firms. Further, the employment impact is only significant for small non-tradable service firms.

Keywords: *Service Sector, Employment, Female Employment*

JEL Classification: *O1, O14, O19*

[*] *bavdiu@worldbank.org*
[†] *k.bagavathinathan@stud.uni-goettingen.de*
[‡] *rchaurey@jhu.edu (Corresponding author)*
[#] *gnayyar@worldbank.org*
[§] The authors would like to thank Banu Demir, Indermit Gill, Robert Z. Lawrence, Denis Medvedev, Sebastien Miroudot, Dilip Mookherjee, participants at the India Policy Forum 2022, and participants at the World Bank's 8th South Asia Economic Policy Network Conference. The opinions expressed in the paper are those of the authors and do not necessarily reflect the views of the World Bank Group or its Board of Executive Directors.

1. Introduction

The peak shares of manufacturing in value added and employment across a range of developing economies, since the 1980s, occurred at lower levels of per capita income than in their high-income, early industrializer precursors (Rodrik 2016). This "premature" deindustrialization reflects a structural transformation where the services sector has grown relatively faster. Much like manufacturing (Rodrik 2013), this services growth has been characterized by unconditional convergence of productivity to the frontier: countries starting from lower labor productivity in the services sector grew faster between 1975 and 2012 than those with higher initial labor productivity in that sector (Kinfemichael and Morshed 2019).

Much of this catch-up is attributable to tradable services, such as ICT (information and communications technology), business, and financial services, that are offshorable just like goods. Digital technologies have boosted trade in these services (Freund and Weinhold 2002), many of which now have trade costs comparable to manufacturing industries (Gervais and Jensen 2019). Tradable services have also had broader productivity impacts because they enable trade in goods. There is evidence, for instance, which finds that the liberalization of telecommunications and transportation services has improved the productivity of downstream manufacturing firms (Arnold et al. 2016; Bas 2014).

However, many of these tradable services are also typically skill-intensive (Nayyar et al. 2021a; Amirapu and Subramanian 2015; Nayyar 2012a). Large numbers of low-skilled workers are often employed in services, such as retail and hospitality, that are associated with a high intensity of face-to-face interaction between consumers and services providers. And while there is some evidence to suggest that these non-tradable services have contributed to productivity growth (Fan et al. 2021), demand is typically constrained by the size of the local market. This reduces workers' opportunities to benefit from international trade. The question therefore is whether less traded services that often account for the lion's share of services employment in developing economies can benefit from services trade.

In this paper, we study the effect of the growth of employment in tradable services on the growth of employment in non-traded services, across Indian districts, between 1998 and 2013. India provides the relevant context given the rapid growth of its export-oriented services, such as software and business process outsourcing, since the 1990s (Eichengreen and Gupta 2011; Nayyar 2012a). In documenting two waves of services-sector growth, Eichengreen and Gupta (2013) show that the share of modern services in output began to rise in a second wave at a level of per capita income of about US $4,000 [in year 2000 US purchasing-power-parity (PPP) dollars terms] before 1990. However, this wave started at lower levels of per capita income after 1990 than in the preceding four decades. India—which experienced a dramatic growth of its

software and business services sector during the decades since 1980—had a per capita income level of about US $3,300 (in year 2000 PPP dollars terms) in as late as 2009. However, evidence also shows that the export of these services has benefited skilled workers more than unskilled workers in India (Mehta and Hasan 2012). As a result, there are concerns that a labor-abundant economy, such as India, cannot rely on information technology-related services to facilitate structural transformation. These concerns can be alleviated, at least in part, to the extent that the growth of tradable services boosts job creation in non-tradable services.

The main challenge in analyzing the question is that time-varying unobservable district-level characteristics may be correlated with district-level changes in employment in both tradable and non-traded services. This would preclude us from making any policy-relevant causal conclusions on the strength of the relationship between growth in tradable and non-traded services. Ideally, we would like to generate exogenous variation in the growth in tradable services employment and the current proportion of workers in the district that are affected by the growth in tradable services. We rely on changes in foreign demand shocks (world import demand changes) for these services that are otherwise unrelated to increases in employment in non-traded services, to obtain exogenous variation in employment growth in tradable services sectors ("shift"). This exogenous employment growth in tradable services common to all districts, however, would have differential effects across districts, depending on their current employment shares in these services. We rely on the initial district-level employment shares in traded services ("share") to obtain exogenous variation in the current district-level employment shares in these services. We therefore use a district-specific shift-share "Bartik-type" instrumental variable, following Hummels et al. (2014), that is the average change in world import demand – excluding India – for tradable services weighted by the initial employment shares of these services across districts. Using the instrumental variable strategy, we find that a 10 percent increase in tradable services employment leads to a 4.2 percent increase in non-traded services employment. Furthermore, such an increase in tradable services employment increases the number of firms in non-tradable services by 2.8 percent.

Although we find a positive impact of the growth in tradable services on non-traded services in Indian districts, it is important to understand the potential mechanisms driving this relationship. Both the demand-side factors and sectoral linkages may have played a role. On the one hand, the growth in tradable services employment may have raised income levels in the district, in turn leading to higher consumer demand for local non-traded services (demand-side channel). On the other hand, the growth in tradable services may have led to the growth in those non-tradable services that have strong input-output linkages (sectoral-linkages channel). We find stronger suggestive evidence that demand-side factors rather than the supply-side factors explain the relationship between

the growth in tradable and non-tradable services in Indian districts. First, we find that non-traded services that benefit the most from tradable service growth have very low input-output linkages. Next, we find that household expenditure on key non-tradable services increased in districts that were exposed to larger increases in employment among tradable services.

Studying the consequences of services trade on non-tradable services is also important given that women might be disproportionately affected. This is because of their comparative advantage in non-traded pink-collar services occupations, such as teaching, residential care, social work, nursing, and personal services – as they were in the United States between 1950 and 1970 (Goldin 2006). The literature also finds that female entrepreneurs tend to be predominantly in non-tradable services, such as retail (Bank 2022; Bardasi and Terrell 2011). Assessing the effects on non-tradable services, where women are more likely to work, becomes especially critical in the Indian setting where women's labor force participation remains low (Chiplunkar and Goldberg 2021).

Furthermore, services establishments tend to be significantly smaller than manufacturing establishments, especially those in non-tradable services, such as retail trade. This observed gap in establishment size can be explained, at least in part, by the extent of informality. Non-tradable services, such as retail and personal services, comprise a large part of the informal sector in developing economies (Nayyar et al. 2021b). Informality plays a role in explaining size differences between services firms across developing and developed economies. Based on evidence from Latin America, Alfaro and Eslava (2020) show that the exclusion of the informal sector, which is more pervasive in developing economies, reduces the size gap between services firms across countries at different levels of per capita income. Therefore, analyzing the heterogeneous effects of the growth in non-tradable services by firm size is also important, especially in the Indian context where informality pervades the services sector. There are also overlaps between gender and firm size. Women are more likely than men to operate in informal firms that are typically smaller (Hallward-Driemeier 2013).

We, therefore, look at gender and firm size as two important margins of heterogeneity. We find that magnitude of the impact is much larger for female workers; a 10 percent increase in tradable services employment leads to a 9.1 percent increase in non-traded services employment for women compared to 4.2 percent for men. We find even larger differences between female-owned and male-owned firms. A 10 percent increase in tradable services employment leads to a 13.7 percent increase in female-owned firms in non-traded services for women compared to a statistically insignificant 1.6 percent increase for male-owned firms. Finally, we find that the effects are only significant for small non-tradable service firms (for firms between 1–10 workers).

Our paper contributes to several strands of literature. First and foremost, our paper is related to the literature on structural transformation into the services sector. Eichengreen and Gupta (2013) find that the growth of modern, tradable services—finance, ICT, and business services—started at lower levels of per capita income after 1990 than in the preceding four decades, thereby benefiting developing economies relatively early in their structural transformation process. Furthermore, the growth of these services has improved educational outcomes. Oster and Steinberg 2013 show that the IT revolution in India boosted the enrollment of girls and boys, equally, in schools with English as the language of instruction. Nano et al. (2021) find that employment growth in telecommunications and financial services, boosted by liberalization in these sub-sectors, increased school enrollment rates. As a result, the increase in the skill premium was also less pronounced in India (Shastry 2012). Using data from India, Fan et al. (2021) show that even traditional, non-tradable services have contributed to productivity growth, albeit benefiting consumers at the top of the income ladder more.

Our paper also contributes to the literature on how linkages between the services and manufacturing sectors benefit overall economic growth. A substantial body of evidence across countries shows that the services "embodied" in manufactured goods have a significant impact on manufacturing productivity (Arnold et al. 2016; Arnold et al. 2011; Bas and Causa 2013; Francois and Woerz 2008). Services used as inputs in the manufacturing sector have benefited from growth in the latter too. Evidence from India shows that growth in manufacturing has accelerated growth in value added and worker productivity in services firms within the same geographic region (Dehejia and Panagariya 2016).

We also contribute to the literature on the effects of globalization on non-tradable services. Munoz (2021) analyzes the impact of "posting" policies in the European Union (EU) that enables firms in one country to send ("post") their workers to perform non-tradable services jobs, such as plumbers or drivers, in another country. She finds that firms in previously "non-tradable" services increase their sales, profits and wages when accessing foreign markets through the movement of workers across national boundaries. Such exports of services are less prevalent outside the EU where the movement of labor is constrained by regulatory barriers. Non-tradable services can also benefit from globalization indirectly through greater demand resulting from the growth of knowledge-intensive tradable services, such as ICT and professional services. Frocrain and Giraud (2017) investigate the evolution of employment in the tradable and non-tradable sectors in France and find that 80 additional non-tradable jobs were created for every 100 tradable jobs created in a local employment area between 2008 and 2016. However, they do not distinguish between the services and manufacturing sectors in their analysis.

Last, but not least, our paper contributes to the literature on how services growth is reducing gender gaps. Ngai and Petrongolo (2017) show that the expansion of the services sector, driven by structural transformation and marketization of home production, has raised women's relative wages and market hours in the United States. Ben Yahmed and Bombarda (2019) find that trade liberalization increases the probability of informal employment in the services sector among low-skilled women that is linked – at least in part – to women entering the labor force. Jensen (2012) finds that an increase in labor market opportunities in the business process outsourcing industry increased education and health outcomes of girls, boosted career aspirations, and delayed marriage and fertility decisions of young women. On the consumption side, Atkin et al. (2018) show that female-headed households are likely to benefit more from imports of consumer services because they tend to spend a larger share of their income on, for example, food and retail.

Our paper provides new evidence on a dimension of structural transformation that is often ignored by policymakers who are most concerned with the movement of labor from agriculture to manufacturing. In India, the positive contribution of structural change to economic growth after the 1990s was largely attributable to the expansion of tradable service activities: finance, IT, business process outsourcing (BPO), and other business services (McMillan et al., 2017). The skill-intensity of these services, relative to manufacturing, has raised concerns that large-scale job creation, especially for low-skilled workers, is not as forthcoming. We find that the growth of employment in tradable services has a positive impact on growth of employment in non-tradable services. This impact magnifies the magnitude of employment creation associated with the growth of tradable services.

The rest of this paper is structured as follows. Section 2 discusses the empirical strategy and data, Section 3 presents the results, while Section 4 concludes.

2. Empirical Strategy and Data

2.1. Data

Our main data sources include multiple rounds of the Economic Censuses in India, namely the 3rd (1990), 4th (1998), 5th (2005), and 6th (2013) rounds. The census covers all economic enterprises in the country, except those engaged in crop production and plantations, and provides information on the number of workers hired by each enterprise, number of enterprises, as well as ownership (male/female) of enterprises. We aggregate this information at the district level. However, after 1990 several new districts were created in India. As a result, the administrative boundaries of many districts changed between the various

Economic Census rounds. Therefore, we reclassify the newly formed districts to their original district administrative boundary in 1990. In total, therefore, we have 433 districts in our data.

We also use National Sample Survey Consumer Expenditure (NSS CES) rounds 55 (1999–2000), 61 (2004–05), and 68 (2011–12), for household expenditure data. To explore linkages between tradable and non-traded services sectors, we use the Indian Input Output Transactions (IOT) Table from 2006–2007. Lastly, the trade data for world import demand for services sector comes from the World Input-Output Database (WIOD) database, as described in Timmer et al. (2015).

2.2. Classifying Tradability

Our discussion of tradable and non-tradable services first requires a classification. To classify sectors into tradable and non-tradable, a popular approach is to analyze the geographic dispersion of industries, following Jensen and Kletzer (2006). However, Gervais and Jensen (2019) have recently improved upon this approach by constructing a classification based on implied trade costs.

Due to data limitations, we cannot estimate trade costs in the same way as Gervais and Jensen (2019). Instead, we follow the approach proposed by Head and Ries (2001) and then adapted by Chen and Novy (2011) using data from the WIOD.

In this sense, implied bilateral trade costs can be expressed as a ratio of intra-national to international trade flows:

$$\theta_{ij}^{k} = \left(\frac{X_{ii}^{k} X_{jj}^{k}}{X_{ij}^{k} X_{ji}^{k}} \right)^{\frac{1}{2\sigma_k - 1}} \tag{1}$$

Here X_{ii}^{k} and X_{jj}^{k} represent domestic trade of industry k for countries i and j respectively, whereas X_{ij}^{k} are bilateral imports from country i's industry k to country j and σ_k is the elasticity of substitution for industry k.

The more two countries trade with each other (i.e., the higher is X_{ij}^{k} X_{ji}) the lower is the measure of relative trade costs, ceteris paribus. Conversely, if domestic consumption becomes relatively more important in either country, this would indicate larger international trade frictions or lower tradability. Then, sectors with high tradability (low trade costs) are considered tradable, while the rest are classified as non-tradable. Since we are not able to (causally) estimate σ by industry, we follow Chen and Novy (2011) and WTO (2018) in assuming a value of eight across sectors. Note that, as long as we assume a constant value across sectors, the value itself does not change the ranking of trade costs and therefore cannot affect the tradability classification. We then average the bilateral trade costs for India across partner countries. For a few sectors, there is no data on Indian trade available, in which case we take the global average trade costs instead.

Lastly, as in any classification, we must set a threshold for tradability. Since the tradability of manufacturing is well known, we set the threshold for trade costs equal to the highest level for manufacturing, such that all manufacturing is just tradable. This approach has also been applied, for example, in Frocrain and Giraud (2017) and Eliasson et al. (2012). As a result, our tradable service sectors are those that are just as tradable as manufacturing.

Our sample contains 35 broad service sectors, of which 17 are classified as non-tradable. The list of non-tradable and tradable service sectors is shown in Table 2. This classification is fairly similar to a closely related paper on France by Frocrain and Giraud (2017), despite different methodologies.[1] While modern technology is rapidly changing the tradability of services, it is worth noting that our classification intends to be representative for our sample period of 1998–2013, during which time many services were in part not as easily tradable as today.

TABLE 1. Summary Statistics

	1998	*2005*	*2013*
a) Non-tradable Services			
Share of non-tradable in total non-agri employment (%)	55.03	59.80	64.54
Share of women employment (%)	14.19	16.96	22.58
Share of women ownership (%)	4.18	4.72	8.92
Average employment (No.)	2.14	2.04	2.12
% Share of employment in small firm (1–10)	80.09	82.52	81.13
% Share of employment in large firm ($>$ 10)	19.91	17.48	18.87
b) Tradable Services			
Share of tradable in total non-agri employment (%)	2.20	2.41	3.56
Share of women employment (%)	7.38	8.13	11.70
Share of women ownership (%)	2.58	2.38	6.10
Average employment (No.)	2.95	2.55	2.48
% Share of employment in small firm (1–10)	71.60	81.57	84.96
% Share of employment in large firm ($>$ 10)	28.40	18.43	15.04

Source: Using Economic Censuses, 1998, 2005, 2013.

1. Only two of our non-tradable sectors are tradable, according to Frocrain and Giraud (2017). These are rental and leasing activities and travel agencies, with the difference likely due to the older time period which we examine, i.e., when physically going to a travel agency may have largely been necessary.

Some relevant summary statistics are presented in Table 1. The share of non-tradable services in total non-agricultural employment was overwhelmingly large, increasing from 55 percent in 1998 to 65 percent in 2013. The corresponding share of tradable services was as low as 4 percent in 2013. Women workers comprised 14 percent of total employment in non-tradable services in 1998 and this increased to 23 percent by 2013. The share of women-owned firms in non-tradable services similarly increased, albeit from a lower base. The corresponding shares of women workers and women-owned firms was lower in tradable services. Furthermore, the share of employment among small firms (less than workers) in non-tradable services, at more than three-fourths, was consistently large between 1998 and 2013.

TABLE 2. List of Tradable and Non-tradable Services

Tradable Services	*Non-tradable Services*
Sea and coastal water transport	Wholesale trade
Inland water transport	Retail trade
Air transport	Land transportation activities
Warehousing	Postal and courier activities
Support activities for transportation	Accommodation and food service
IT services	Financial and insurance activities
Picture, video and television program	Real estate activities
Broadcasting and programming activities	Legal and accounting activities
Architectural and engineering activities	Rental and leasing activities
Technical testing and analysis	Employment activities
Scientific research and development	Travel agency, other reservation services
Advertising	Education
Photographic activities	Health
Creative, arts and entertainment activities	Residential care activities
Libraries, archives, museums and cultural	Personal service activities
Sports activities	Repair of computers, personal and household goods
Other amusement and recreation activities	Veterinary activities
Activities of business, employers, professional member organizations	

Source: Authors' classification following Frocrain and Giraud (2017).

2.3. Estimation and Identification

We are interested in the effects of district-level changes in tradable service employment on non-tradable services employment. Hence, the baseline equation we estimate is given by:

$$\ln NT_{rt} = \beta_1 \ln T_{rt} + X_{rt} + \varepsilon_{rt} \quad (2)$$

Here $\ln NT_{rt}$ and $\ln T_{rt}$ respectively denote the log annual employment of non-tradable and tradable services in district r in time t, where $t \in \{1998,2005,2013\}$, while X_{rt} is a vector of various controls, including fixed effects. As an extension, we also estimate the effect on firm creation, where $\ln NT_{rt}$ represents the log number of non-tradable firms. To avoid observations with a zero value from dropping out due to logs, we also take a hyperbolic sine transformation. However, the results are also robust without it.

The parameter of interest β_1 captures the effect of local tradable service employment on the employment of non-tradable services in region r. Nevertheless, β_1 might still be biased, for instance, because unobserved time-varying district-level demand and supply shocks could affect both tradable and non-tradable service employment in districts.

We aim to establish a causal link by exploiting plausibly exogenous variation in tradable service activity, which does not have a direct effect on non-tradable services. As an instrument, we make use of world service import demand, excluding India. An increase in world demand for imports would create an exogenous demand increase for tradable services but not directly for Indian non-tradable service firms. We then construct region-specific Bartik shocks that reflect exposure to world import demand changes following Hummels et al. (2014).

Hence, $\ln T_{rt}$ will be instrumented by a shift-share Bartik-type instrument Z_{rt} based on the weighted average of foreign demand shocks faced by local tradable service firms in region r. The instrument is constructed as follows:

$$Z_{rt} = \Sigma_k \alpha_{rk} \ln X_{kt} \quad (3)$$

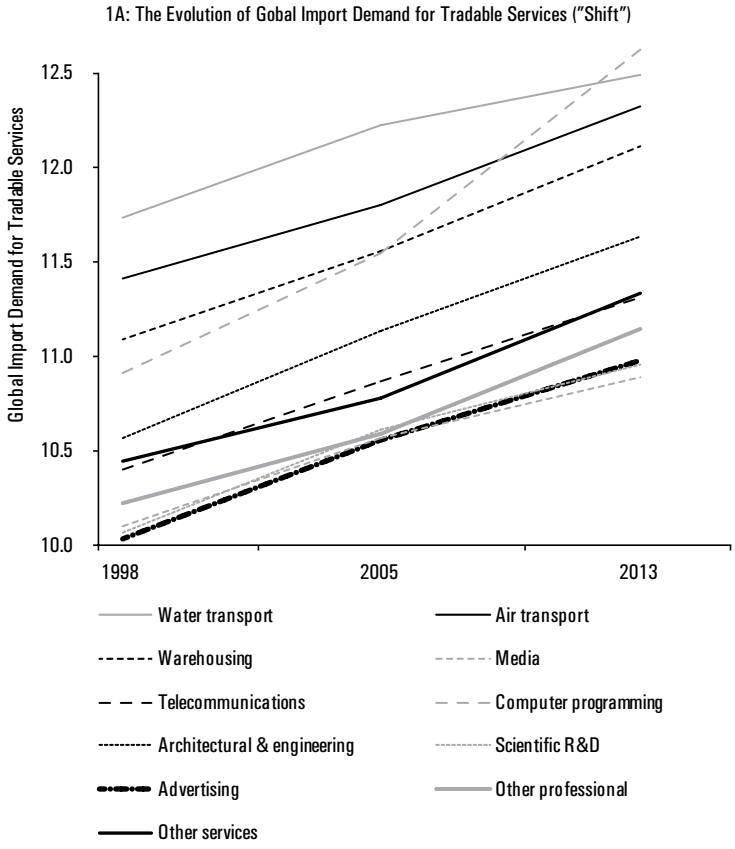
where $\ln X_{kt}$ denotes the log world imports excluding India of tradable service sector k at time t, and α_{rk} captures the employment share of tradable service industry k of region r in aggregate tradable service employment in that region in the base year 1990. We have:

$$\alpha_{rk} = \frac{T_{rk}}{\Sigma_K T_{rk}} \quad (4)$$

In short, Z_{rt} supposedly captures an exogeneous component (namely foreign demand) of the growth in the tradable service sector, by district.

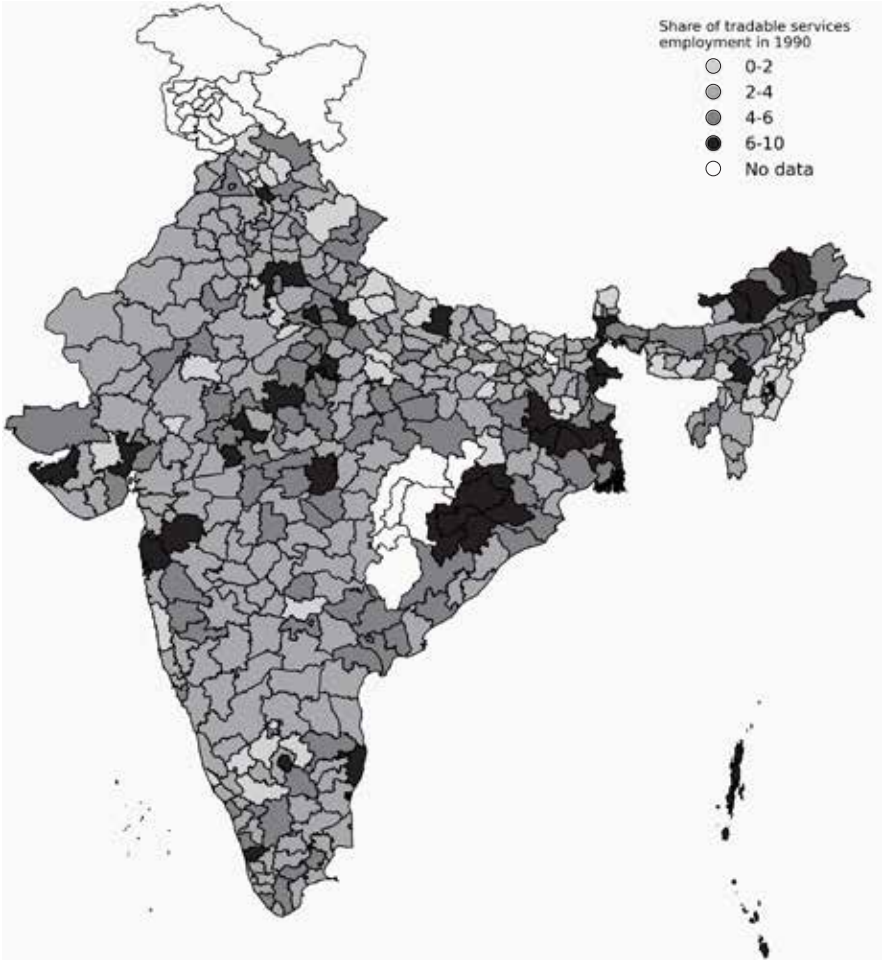
Figure 1 visually depicts the instrumental variable. Figure 1A depicts our "shift" component, i.e., log global import demand (excluding India) for tradable services. As can be seen, global demand for all tradable services has been growing strongly in the time frame of our sample. Figure 1B shows the share of tradable service employment by district in India, i.e., the "share" component of the instrument. The districts with a higher share would have a stronger exposure to services trade and therefore be more affected by the increase in global demand.

FIGURE 1. Visual Depiction of the Shift-Share Instrumental Variable



Source: Using WIOD data.

1B: Tradable Service Employment Share in 1990 ("Share")



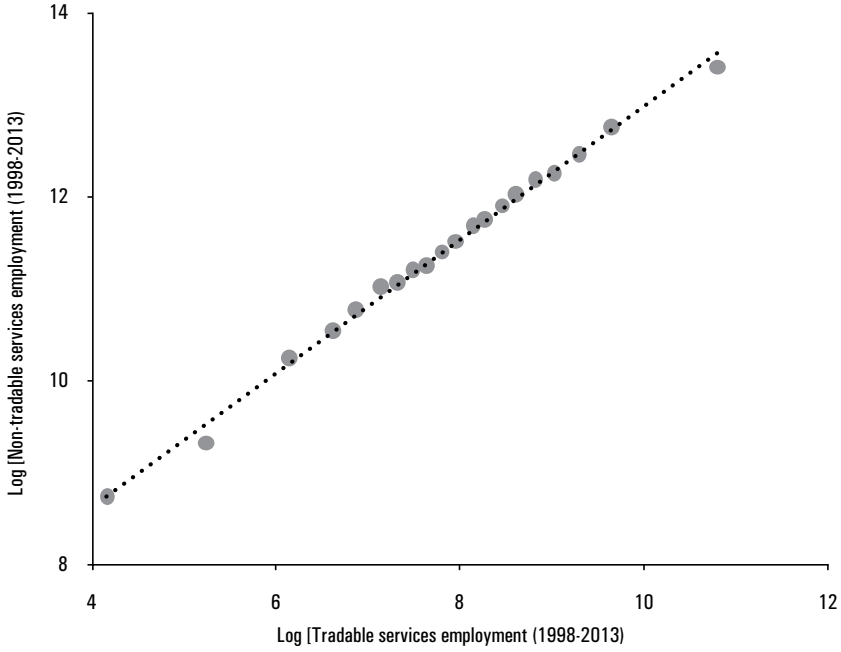
Source: Using Economic Census 1990.

3. Results

3.1. Baseline Results

Before discussing the regression results, we first visually plot the OLS relationship between district-level log (non-tradable services employment) and log (tradable services employment) between 1998–2013 in Figure 2. As is visually clear, there is a strong positive correlation between the tradable and non-tradable services sector employment.

FIGURE 2. Binscatter Plot of the Relationship between Log (Non-tradable Services Employment) and Log (Tradable Services Employment)



Source: Using Economic Censuses, 1998, 2005, 2013.

Table 3 shows the corresponding regression results from estimating our baseline equation 2. Our main explanatory variable is the district-level log of tradable service employment. We make use of two dependent variables. Columns (1)–(3) show the effects on the district-level log of non-tradable service employment, while columns (4)–(5) use the log number of firms in non-tradable services. In both cases, OLS coefficients in columns (1) and (4) are positive and statistically significant.

To address endogeneity concerns, we now turn to the instrumental variables approach.[2] According to our main IV specification in column (2), we see that a 10 percent increase in tradable services employment leads to a 4.23 percent increase in non-tradable employment. This implies that approximately 7.6 non-tradable services jobs are created for each new tradable service job, considering the average total non-tradable employment in our sample is 40,054, compared to 2,221 for tradables. Such an increase in tradable employment increases the number of firms in non-tradable services by 2.85 percent, as shown in column (5), though the coefficient is now only significant at the 10 percent level. Given

2. The first stages of our baseline have an F-statistic value of 10.9, above the rule of thumb value of 10 for weak instruments.

the smaller coefficient and lower significance of the effect on the number of firms, it seems likely that the positive employment spillovers are more due to the expansion of existing firms (the intensive margin), rather than new firm creation (the extensive margin). Notably, the IV coefficients are larger than OLS, possibly due to measurement error related attenuation bias in the OLS regressions.

Furthermore, Goldsmith-Pinkham et al. (2020) have recently raised concerns that Bartik instruments may suffer from endogeneity of the lagged shares and recommend using control variables that help ensure that the initial distributions of tradable and non-tradable services are not biased. A natural candidate in our case is the level of education by district, which we proxy by the literacy rate. These results are shown in columns (3) and (6). Overall, the coefficients remain rather similar in statistical significance and magnitude compared to the baseline, but the effect on the number of firms is no longer significant.

Our employment estimate of 0.42 is larger, but comparable to Moretti (2010), who finds a coefficient of 0.33 in the US, but includes only manufacturing in the tradable sector. Our estimates are also higher than Frocrain and Giraud (2017), however, who find an elasticity of 0.23 for France for tradable services on non-tradable services.

TABLE 3. Impact of Tradable Services on Non-tradable Services

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
		Employment			*No. of Firms*	
	OLS	*IV*	*IV*	*OLS*	*IV*	*IV*
Log tradable services	0.098***	0.423**	0.418**	0.079***	0.285*	0.279
	(0.017)	(0.190)	(0.203)	(0.017)	(0.170)	(0.181)
Education			0.001			0.001
			(0.007)			(0.005)
Observations	1,173	1,173	1,173	1,173	1,173	1,173
District FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes

Source: Using 1) Economics Censuses, 1990, 1998, 2005, 2013; 2) National Sample Survey Consumer Expenditure (NSS CES), Rounds 55 (1999-2000), 61 (2004-05), and 68 (2011-12); and 3) WIOD data.
Note: Standard errors (in parentheses) are clustered at the district level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.2. Mechanisms

There are two main channels through which an increase in tradable activity can generate growth in non-tradable services. First, the effect could come from sectoral linkages. The growth in tradable services may lead to growth in input-supplying non-tradable services, or conversely, growth in tradable services

could make tradable service inputs into non-tradable services cheaper or of higher quality. This in turn could spur non-tradable service growth in input-receiving sectors. Alternately, on the demand-side, tradable service growth may increase local income, which in turn increases consumer demand for non-traded services. Whether the sectoral linkages or demand-side mechanisms explain our main results is ultimately an empirical question.

We consider the sectoral linkages channel first. To explore this, we use the Indian input-output tables from 2006–07, that shows the linkages of non-tradable service sectors to and from tradable services, as a share of inputs to/from all the sectors in the economy. We use this to categorize non-tradable service sectors into four categories: (i) sectors that provide a below median (low) share of inputs to tradable services, (ii) sectors that provide an above median (high) share of inputs to tradable services, (iii) sectors that receive a below median (low) share of inputs from tradable services, and (iv) sectors that receive an above median (high) share of inputs from tradable services.

To test for the sectoral linkages channel, in Table 4, we estimate separate regressions for district-level employment in each of these 4 categories in response to an increase in tradable services employment. In column 1, we find that district-level employment increased in non-tradable services sectors that provide a low share of inputs to tradable sectors, but there is no statistically significant change in the employment in non-tradable sectors that provide a high share of inputs to tradable sectors (column 2). Similarly, in columns 3 and 4, we find that district-level employment increases in non-tradable services sectors that receive a low share of inputs from tradable sectors, but there is no statistically significant change in the employment in non-tradable sectors that receive a high share of inputs from tradable sectors. Taken together, we find that in response to increased district-level employment growth in tradable services, there is an increase in district-level employment in non-tradable service sectors that have low input-output linkages with the tradable services sector.

Next, we consider the consumer demand channel. Following Fan et al. (2021), we analyze the group of non-tradable consumer services, which are largely demanded by local consumers and not used as inputs. As they discuss in their application to India, the expenditure share of consumer services increases with income, but is virtually unrelated to demand from producers. In our case, consumer services following Fan et al. (2021) correspond to: (i) retail trade, except of motor vehicles and motorcycles, (ii) personal services, (iii) human health, (iv) residential care, and (v) accommodation and food services, which were largely drivers of the baseline results. We consider all other non-tradable services to be non-consumer services.

TABLE 4. Sectoral Linkages Channel: Impact of Tradable Services on Employment in Non-tradable Services

	(1)	*(2)*	*(3)*	*(4)*
	Input to		*Input from*	
	Low	*High*	*Low*	*High*
Log tradable services	0.0711**	0.0118	0.0574*	0.0450
	(0.0314)	(0.0212)	(0.0331)	(0.0318)
Observations	1,173	1,173	1,173	1,173
District FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Source: Using 1) Economic Censuses, 1990, 1998, 2005, 2013, and 2) WIOD data.
Note: Standard errors (in parentheses) are clustered at the district level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Column 1 includes district-level employment in health, education, accommodation and food services, legal and accounting activities. Column 2 includes district-level employment in veterinary, repair, residential care, wholesale and retail, transport, postal, finance, real estate activities and rental leasing, employment activities, and travel agency. Column 3 includes district-level employment in health, education, real estate activities and rental leasing services, and legal and accounting activities. Finally, column 4 includes district level employment in veterinary, repair, personal and residential care, wholesale and retail, transport, postal, finance, real estate activities and rental leasing, employment activities, and travel agency, and accommodation and food services.

As shown in Table 5, the effects of tradable services on non-tradables are indeed driven by consumer services. The coefficients on employment and firms are statistically significant, with coefficients of 0.51 and 0.39, respectively. Conversely, the effects on non-consumer services are smaller and insignificant. As consumer services tend to not have input-output linkages with tradable services, this provides additional suggestive evidence for the consumer demand channel.

TABLE 5. Impact of Tradable Service on (Non-tradable) Consumer Services

	(1)	*(2)*	*(3)*	*(4)*
	Consumer Services		*Non-consumer Services*	
	Employment	*No. of Firms*	*Employment*	*No. of Firms*
Log tradable services	0.511**	0.386*	0.340	0.103
	(0.250)	(0.215)	(0.221)	(0.204)
Education	-0.003	0.003	0.011	0.005
	(0.009)	(0.007)	(0.009)	(0.006)
Observations	1,173	1,173	1,173	1,173
District FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Source: Using 1) Economic Censuses, 1990, 1998, 2005, 2013, 2) National Sample Survey Consumer Expenditure (NSS CES) Rounds 55 (1999-2000), 61 (2004-05), and 68 (2011-12), and 3) WIOD data.
Note: Standard errors (in parentheses) are clustered at the district level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Consumer services are: (i) retail trade, except of motor vehicles and motorcycles, (ii) personal services, (iii) human health, (iv) residential care, and (v) accommodation and food services. Non-consumer services are all other non-tradable services.

Finally, to further assess the consumer demand channel, we examine the impact of tradable service employment on consumption expenditure by category, at the household level in Table 6. To be consistent with previous literature, following the analysis on district-level household expenditure in India in Fan et al. (2021), we use state fixed effects instead of district fixed effects. Column (1) shows that a 10 percent increase in tradable service employment leads to a 3.6 percent increase of household expenditures on education, which is significant at the 1 percent level. This is consistent with the argument that spillovers from tradable service growth on education are due to increases in local final demand from consumers. We find similar effects for other important non-tradable services, although differences in sector classifications do not allow us to test each of the sectors driving our results separately. Column (2) analyzes medical services, but these are insignificant. Column (3) shows a highly significant coefficient of 0.53 for entertainment. Similarly, the effects on consumer services and the total of these services are also large (at 0.26 and 0.29, respectively) and statistically significant. Lastly, column (6) shows positive and significant effects on the overall monthly per capita expenditure (MPCE) of households.

In sum, we find suggestive evidence that the consumer demand channel rather than the sectoral linkages channel, plays a larger role in explaining the relationship between the district-level growth in non-tradable and tradable services employment.

TABLE 6. Impact of Tradable Services on Consumption Expenditure

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
	Education	*Medical*	*Entertainment*	*Consumer*	*Total Services*	*MPCE*
Log of tradable services	0.360***	0.114	0.532***	0.257***	0.287***	0.149***
	(0.0793)	(0.105)	(0.107)	(0.0859)	(0.0764)	(0.0300)
Education	0.0268***	0.00712	-0.00774	0.0115*	0.0173***	0.00469**
	(0.00605)	(0.00808)	(0.00742)	(0.00631)	(0.00561)	(0.00213)
Observations	330,915	330,915	330,915	330,915	330,915	330,915
State FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes

Source: Using 1) Economic Censuses, 1990, 1998, 2005, 2013, 2) National Sample Survey Consumer Expenditure (NSS CES), Rounds 55 (1999-2000), 61 (2004-05), and 68 (2011-12), and 3) WIOD data.

Notes: Includes controls at household level for owning land (to proxy wealth) and household size, to normalize expenditures per person. Dependent variables and land owned are transformed using the inverse hyperbolic sine function. Observations are weighted by the sample multiplier. Education expenditure comprises library charges, tuition and related fees, private tutor/coaching and other educational expenses. Medical expenditure includes all medical expenditure, except medicine. Entertainment expense includes: i) cinema and theatre, ii) *mela*, fair, picnic, iii) club fees, iv) goods for recreation and hobbies, v) photography, and vi) other entertainment. Consumer services are comprised of i) domestic servant, cooks sweeper, ii) barber, beautician and related, iii) washerman, laundry, ironing, iv) tailor, v) priest, vi) legal expenses, vii) postage telegram, viii) telephone charges, and ix) repair charges for non-durables and other consumer services excluding conveyance. Total services are the total of education, medical, entertainment, and consumer services.

Standard errors (in parentheses) are clustered at the district level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.3. Heterogeneous Effects

Women's labor force participation may have benefited disproportionately from structural transformation into the services sector. On the one hand, this is attributable to their comparative disadvantage in performing manual labor-intensive tasks associated with the manufacturing sector.[3] On the other hand, large numbers of women in developing economies are employed in non-traded services, such as teaching, residential care, social work, nursing, and personal services, and may have gained through increased consumer demand resulting from the growth in tradable services (as we show earlier). Therefore, analyzing the heterogeneous effects of the growth in non-tradable services by gender is critical, especially in the Indian setting where women face substantial barriers to labor force participation (Chiplunkar and Goldberg, 2021).

TABLE 7. Impact of Tradable Services on Non-tradable Services, by Gender

	(1)	*(2)*	*(3)*	*(4)*
	Employment		*No. of Firms*	
	Women	*Men*	*Women*	*Men*
Log tradable services	0.910**	0.425**	1.376*	0.160
	(0.411)	(0.206)	(0.709)	(0.193)
Education	0.012	0.001	0.027	0.001
	(0.013)	(0.007)	(0.019)	(0.006)
Observations	1,173	1,173	1,173	1,173
District FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Source: Using 1) Economic Censuses, 1990, 1998, 2005, 2013, 2) National Sample Survey Consumer Expenditure (NSS CES), Rounds 55 (1999-2000), 61 (2004-05), and 68 (2011-12), and 3) WIOD data.
Note: Standard errors (in parentheses) are clustered at the district level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In Table 7, we analyze the effects of district-level increases of employment in tradable services on employment and number of firms in non-tradable services sector for women and men separately. To this end, in columns (1) and

3. For example, Pitt et al. (2012) show that men in Bangladesh obtain less schooling and sort into production occupations with lower returns to skill (and higher rewards for brawn), while the average payoffs to schooling are higher for women who specialize in skill-intensive activities. Similarly, Munshi and Rosenzweig (2006) find that lower-caste networks in India continue to channel boys into local language schools that lead to traditional blue-collar occupations, while lower-caste girls who did not benefit from these networks owing to low labor market participation rates switched rapidly to English schools that have become more widespread. Juhn et al. (2013) find that the adoption of computerized production processes – induced by trade liberalization associated with the North American Free Trade Agreement (NAFTA) – among Mexican establishments raised the relative wage and employment of women by lowering the need for physically demanding skills.

(2) respectively, we only keep either female employees or male employees in the sample, before aggregating at the district level. For the number of firms in columns (3) and (4), we only keep either female-owned or male-owned businesses. Overall, the effects for women are much stronger. Column (1) shows a coefficient on non-tradable employment of 0.91, compared to 0.43 for men, as shown in column (2). The gender difference is even more pronounced when analyzing the number of firms in columns (3)–(4), with a coefficient of 1.38 for female-owned business, albeit only significant at the 10 percent level. Conversely, the coefficient for male-owned businesses is close to zero and insignificant. These results suggest that district-level growth in tradable services employment increases both female employment and female owned firms (entrepreneurship). This is important because Chiplunkar and Goldberg (2021) show that promoting female entrepreneurship can in turn lead to higher female labor force participation because women entrepreneurs hire more females.

Lastly, we now turn to the heterogeneous effects by firm size. The average size of establishments in tradable services, such as ICT, is comparable to the manufacturing sector across countries at different levels of per capita income. However, the average services establishment in non-traded services is relatively small. In developing economies, informality plays an important role here because many services firms across, for example, small-scale retail and personal services are unregistered. Even when the analysis is restricted to formal firms, non-tradable services, such as retail, vehicles trade, real estate, have the smallest average firm size, which is about four to five times smaller than a manufacturing firm in the same country (Nayyar et al., 2021b). Therefore, analyzing the heterogeneous effects by firm size is important, especially in the Indian context where informal establishments constitute a large share of value added in non-traded services, such as retail, real estate, and personal services (Nayyar, 2012b).

TABLE 8. Impact of Tradable Services on Non-tradable Employment by Size

	(1)	*(2)*	*(3)*	*(4)*
	1-10	*11-30*	*31-50*	*> 50*
Log of tradable services	0.391**	0.284	0.512	0.413
	(0.177)	(0.297)	(0.424)	(0.700)
Observations	1,173	1,173	1,173	1,173
District FE	yes	yes	yes	yes
Year FE	yes	yes	yes	yes

Source: Using 1) Economic Censuses, 1990, 1998, 2005, 2013, and 2) WIOD data.
Note: Standard errors (in parentheses) are clustered at the district level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In Table 8, we examine a sub-sample analysis for the employment effects by firm size. In doing so, we consider four size groups, non-tradable service sector firms with 1–10 employees (column 1), 11–30 employees (column 2), 31–50 employees (column 3) and more than 50 employees (column 4). As can be seen, the only significant effects are among the smallest group of firms, with a coefficient of 0.39. Hence, the employment effects from tradable service growth are most relevant for the smaller non-tradable service firms.

4. Conclusion

Structural transformation toward high-end services and increased trade have been important growth drivers in India and beyond. However, tradable services growth can also have positive spillover effects on non-tradable services, which cannot benefit directly from globalization and trade-enhancing technological advances. In particular, these effects may have important distributional outcomes between men and women. While similar linkages between manufacturing and services have been well explored, spillovers between tradable and non-tradable services have been understudied.

We find that a 10 percent increase in tradable services employment leads to a 4.2 percent increase in non-tradable services employment. There is also an increase in the number of firms in non-tradable services by 2.8 percent, but this result is less statistically significant. The employment impact is much larger for female workers; a 10 percent increase in tradable services employment leads to a 9.1 percent increase in non-traded services employment for women compared to 4.2 percent for men. Similarly, we also find larger effects on the number of female-owned firms, compared to male-owned firms. Further, we find that the effects are only significant for small non-tradable service firms. Our evidence also suggests that this positive impact is likely due to an increase in consumer demand for local non-tradable services that results from the growth in tradable services employment.

Our paper makes an important contribution to the literature by showing that international trade can benefit non-tradable services. This is enabled through increased household demand for non-tradable services, resulting from the growth of tradable services. The result does not preclude other ways in which non-tradable services can benefit from international trade. For instance, employment in non-tradable services can benefit from increased household demand resulting from the growth of other traded sectors, such as manufacturing or agriculture. Non-tradable services can also be indirectly exported through forward linkages with these goods-producing sectors. Future research on the role of the services sector in India's structural transformation can assess these relationships.

An avenue for future research can also examine the impact of growth in tradable services on non-tradable services in terms of output and productivity.

However, this would require moving beyond the Economic Census data that only contain information on the number of workers. Services firms, however, are not covered adequately in India's official statistics. The absence of good and comprehensive data for services firms, especially in a panel format, poses difficulties to estimate the technical efficiency or total factor productivity. The absence of regular data on informal firms is also particularly problematic for the services sector. Informal firms are, by definition, excluded from administrative data sources, such as tax records or business registers. Further, the informal sector surveys conducted by the National Sample Survey Organization are few and far between. These issues are symptomatic of gaps in the coverage and reporting of data on services firms in other countries too. Better and more complete data are crucial to fully grasp the growing contribution of the services sector to growth and structural transformation.

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Comments and Discussion*

Chair: **Indermit Gill**
World Bank

Robert Z. Lawrence
Harvard Kennedy School

This paper makes an important contribution to the current Indian debate over the implications of services export-led growth. Indirectly, it could also contribute to an understanding of the regional effects in many countries of enhanced opportunities for providing services and remote work that have emerged as a result of the Covid experience.

The paper's results should also offer pause to those who believe that the only path for Indian development is to emulate the model of the Asian tigers and use labor-intensive manufactured goods exports to drive economic growth. Proponents of this view believe that this strategy not only fits India's pattern of factor endowments, in particular its large labor pool of unskilled workers, but also leads to more inclusive growth by providing opportunities for these workers with low levels of education to leave agriculture and raise their incomes by working in manufacturing. Another reason often given for favoring manufacturing growth is that it generates forward and backward linkages to other sectors.

Yet despite the promise of such growth, India has a low and fairly constant share of manufacturing employment and runs perennial deficits in manufactured goods trade. Instead, the growing share of overall employment and the most dynamic part of its export sector consists of services. This is seen as a problem by those advocating an approach that emphasizes manufacturing because services exports are relatively intensive in the use of skilled labor and because those who favor manufacturing doubt that services exports will generate the kinds of linkages to other sectors that are associated with manufacturing. Partly in response to such concerns, India has increased its emphasis on policies that emphasize manufacturing employment and has recently implemented an ambitious policy to increase manufacturing output by providing Production Linked Incentives. (PLIs).

* To preserve the sense of the discussions at the India Policy Forum, these discussants' comments reflect the views expressed at the IPF and do not necessarily take into account revisions to the conference version of the paper in response to these and other comments in preparing the final, revised version published in this volume. The original conference version of the paper is available on NCAER's website at the links provided at the end of this section.

However, this paper suggests that it may be necessary to revise views of services export-led growth as non-inclusive and not generating significant spillovers to other sectors. The paper finds that though tradeable exports are skill-intensive, these exports also generate spillover effects that increase the demand for non-tradeable services. These spillovers provide opportunities for greater inclusion both through increasing employment opportunities for less skilled workers and by raising the profits of female-owned firms.

The paper reminds us of the importance of taking a general equilibrium view of structural change rather than a view that focuses only on a sector of concern. As the authors note, growth in a sector can impact growth in other sectors: (a) on the supply side by generating increased demand for inputs and offering opportunities for output distribution, and (b) on the demand side, by raising incomes and stimulating spending on the output of other sectors. An important result of the paper is that the spillover impacts of tradable exports operate primarily through the demand channel. This link between growth in one sector and its spillover effects operating through demand is a vital property of structural change that is often overlooked. It seems natural, for example, that industrial policies that stimulate production directly in a sector (such as through Production-Linked Incentive Schemes or PLIs) are the right way to increase sector output and employment but two examples are worthy of note.

First, in many countries, the most important source of growing demand for workers in manufacturing are the spillovers that come from greater productivity in agriculture. This is because productivity growth reduces agricultural prices and substitution elasticities are less than one increases the demand for manufactured goods. Thus, agriculture and manufacturing are complements. In addition, when income elasticities are less than one for agriculture (Engel's law), higher income generated by productivity improvements in agriculture will increase spending on manufactured goods and services.

Second, it is commonly claimed that the introduction of robots will reduce employment and relative skill premiums by displacing unskilled workers. However, in an insightful paper on the impact of automation in the manufacturing sector, Autor and Dorn (2013) show that though skill-biased technical change can reduce the employment of unskilled workers in manufacturing, the enhanced productivity generated by such technical change can raise incomes and spending on services and thus raise the demand for these same workers in services. Indeed, they find that under plausible assumptions, it is possible that skill-biased technical change in manufacturing can actually raise the relative wages of unskilled workers (Autor and Dorn 2013)! There is evidence in support of this theory. Gregory et al. (2018) examine technological progress in manufacturing on the overall demand for labor when it is biased against routine labor. Using data from 27 European countries between 1999 and 2010, they find that though the direct impact of automation that substituted for routine workers resulted in substantial labor displacement, this was outweighed

by a combination of increased product demand from the sectors experiencing the productivity improvements and the spillovers in increased demand for the output of the non-traded sector (Gregory et al. 2021).

The paper's results could also have predictive power for developments in both India and the United States in response to the increased use of Internet technologies such as Zoom in facilitating remote work. In the United States, over the past two decades, regional growth has become increasingly unequal. On the one hand, "superstar cities" such as San Francisco, Seattle Washington, D.C., and Boston, have grown rapidly. On the other hand, a large number of semi-rural towns which were once manufacturing hubs, have experienced stagnation. Generally, the advice given to these forsaken places is either to allow their people to leave or to adopt policies that attract companies that produce tradable goods and services. However, there is now another option for these places: attract high wage workers who still work in the superstar cities by offering them cheaper and better housing and the ability to avoid commuting by working at home. Once they relocate, as the work of Moretti shows, these workers are likely to spend significant amount of their incomes on local non-traded services.[1] They are also likely to pay local taxes and allow their communities to offer better amenities such as schools and parks. Thus, there is a new channel for more equitable growth that could reduce regional disparities. Similar forces could allow Indians who are skilled to work in the US and other high-income countries, but live and spend in India. The findings in this in this paper, therefore, could be used to support the view that services could become a far more important generator of economic growth and inclusion than has thus far been possible.

The implications of this paper are thus very important for prediction and policies. But are they credible? Actually, the results finding positive employment creation in sectors besides tradable services could be understated for two reasons. Firstly, some of the spending generated by tradable exports could also create jobs in other tradeable sectors such as manufacturing which are not considered in the paper. In addition, because the statistical techniques employ district level data, the spending on non-tradable services that is generated outside each districts is ignored. It is, however, likely that additional jobs would be created by such spending in other districts.

But there is also a potential problem with the central findings of the paper that needs more clarification. As reported in Table 3, the key result is that "a

1. "My research, based on an analysis of 11 million American workers in 320 metropolitan areas, shows that for each new high-tech job in a metropolitan area, five additional local jobs are created outside of high tech in the long run. These five jobs benefit a diverse set of workers. Two of the jobs created by the multiplier effect are professional jobs—doctors and lawyers—while the other three benefit workers in non-professional occupations—waiters and store clerks." (See Moretti 2010; 2013.)

10 percent increase in tradables employment leads to a 4.23 percent increase in non-tradables employment." However, since the employment share in tradable services is very small, —on the order of between 2.2 and 3.56 percent, whereas the share of employment in non-tradable services much larger—between 55 and 64 percent—the effects-attributed to the employment growth in such a small sector on employment in a sector that is between twenty and thirty times larger, are implausibly large! I would find the paper more convincing if in addition to giving the results in terms of sector employment percentages, the authors translated these percentages into number of jobs or even into monetary equivalents. My preference would be to use monetary equivalents, because it is possible that typical incomes in tradeable services which are mainly earned by professionals could be a significant multiple of the typical incomes earned by those who work in non-tradable services. But it would be good to have these numbers. If indeed the orders of magnitude of wages in rupees could offset the differences in employment, the results would be more plausible.

In sum, this has the potential to be a very important paper. It asks, and gives answers to, very important questions. But the analysis of its findings needs to be elaborated and strengthened, if they are to be truly convincing.

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Dilip Mookherjee

Boston University

This paper studies an important question about economic growth in India. Going back to a paper presented in an early IPF volume by Bosworth, Collins, and Virmani (2006-07), the service sector accounted for the largest fraction of India's growth between 1999 and 2004. But within the service sector, the bulk of the contribution came from `traditional' services such as trade, transportation, public and personal services. While the business services and communications sector registered the highest rates of growth, their overall share of sectoral

output was small (5 and 11 percent, respectively in 2004-05, compared to 44 percent for trade and transportation services). What this means is that the true sources of the growth acceleration in India occurring since the 1990s are poorly understood. While technological change and globalization could account for fast growth of the IT sector, how do we explain the sources of growth in traditional `non-traded' services such as trade and transportation which are mostly non-traded and did not experience comparable technical change?

This paper explores the possibility that forward and backward linkages from 'traded service' sectors might explain an indirect but important component of the growth in non-traded services. In other words, growth in business services and communication (IT, hereafter for the sake of brevity) driven by fast growth in export demand and technology may have generated a stimulus to the traditional non-traded service sector. One channel may be the role of the latter in supplying essential inputs to the IT sector. Another could be increasing demand for non-traded consumer services arising from changes in household incomes. Maybe each job created in the IT sector has a multiplier effect—generating three to four jobs in non-traded services? If this were the case, maybe the IT sector was really a 'leading sector' allowing the Indian economy to finally 'take-off'?

An alternative hypothesis has been recently proposed in a working paper by Fan, Peters, and Zilibotti (2022), that fast productivity growth in non-traded consumer services was the driving force behind the growth of this sector. However, no new technology or organizational reforms in transportation, retail or food services in the informal sector have been visibly manifested over the past fifty years. I find the hypothesis advanced by Adviu et al. far more plausible.

This question has important implications for the 'premature deindustrialization' dilemma faced by India among many other developing countries since the 1980s (Rodrik 2016). Should Indian policymakers nevertheless continue to try to revive productivity and jobs in manufacturing with suitable subsidies or by investing more in physical infrastructure that is particularly important for manufacturing success? Can they emulate and surpass the Chinese and Koreans in manufacturing competitiveness? Or should they give up on such a goal as hopelessly utopian, and rely instead on the IT sector where they have a global comparative advantage, which continues to witness fast productivity growth? A common objection to the latter strategy is that IT-sector driven growth may not be inclusive enough as manufacturing growth used to be. If the IT sector did generate large spillovers to traditional services, a subsequent question then pertains to the distributive implications of such spillovers.

The paper addresses all these questions. Answering them is far from straightforward. Estimating spillovers from one sector to another creates challenges for econometric identification: how can one estimate the causal impact of growth in traded services on subsequent growth in non-traded services? Is it possible to dismiss alternative explanations such as local

improvements in supply of skilled workers, credit, de-regulation, government support or infrastructure that may have jointly driven growth in both sets of sectors at the same times and places?

The approach they take is eminently sensible. It is plausible that the domain of indirect forward and backward spillovers to non-traded services will be spatially concentrated in the vicinity of where the bulk of the fast growing IT firms are located, for one would expect firms supplying key inputs to the IT firms would locate close to the latter. And IT sector workers would tend to spend their rising incomes on food, clothing and entertainment near where they live. So if IT was indeed a 'leading sector', we would expect to see faster growth subsequently in non-traded services in districts close to where most of the fast-growing traded service sector firms were located. Moreover, one would require most of the latter growth to be driven by 'external' factors such as technical change or patterns of export demand, rather than changes in local conditions.

For the latter purpose, the authors construct a 'Bartik' instrument, which extracts the effect of growth in traded sectors that were driven by changes in global trade and technology. Applying this methodology requires merging of a panel district-level dataset (based on the Economic Census of Indian firms) for sectoral employment and firm entry for various traded and non-traded services, with data on corresponding world trade volumes for traded services using the same sectoral classification. As is well known, this amounts to an instrumental variable difference-in-difference estimation methodology which washes out effects of variations in levels of unobserved local characteristics.

Data Questions: Sector Classification

Let me start posing some questions about assembly of the dataset. I could not clearly identify how the telecom sector is classified: is it a traded or non-traded sector? This may really matter in the analysis, given the strong role of technological change and growth in this sector during the last three decades. Figure 1 suggests it is treated as a tradable sector, but I wonder if the volume of international transactions in this sector is large enough to merit this classification. Moreover, the sector classifications used in the analysis need to be clarified, as Figure 1 and Table 2 appear to employ a different classification. Figure 1 shows 'computer programming' to have displayed particularly fast growth, but it does not appear in Table 2: is it part of IT services? Moreover, the econometric analysis aggregates all traded sectors and treats it as a homogenous category, and non-traded sectors into a different homogenous category. One would expect the effects to be quite heterogenous, and it would be helpful to understand the role of specific services (such as IT) within the tradable sector, and their impact on specific non-traded services such as transportation and

trade that are known to have grown particularly fast. This would help readers assess whether the hypothesis passes a reasonable 'smell' test.

In a similar vein, I was puzzled by the spatial patterns shown in the map in Figure 1 wherein the largest employment shares for tradeable services appear in States like Assam, Meghalaya, Odisha, East Andhra Pradesh, and parts of central India. At the same time, well known IT and R&D hubs such as Bengaluru or Hyderabad do not appear to be important. One wonders which traded services are driving the quantitative results.

Identification Strategy

As mentioned above, the principal challenge in the empirical strategy is to find a way of isolating the role of external export-cum-technology shocks on the growth of traded services, from improvements in local 'business climate' encompassing infrastructure, supply of skills, credit and local regulations which could have driven growth in both sets of sectors. The standard 'Bartik' instrument uses employment shares in some base year to weight global changes in sector shares, as a proxy for exposure to external shocks. As Goldsmith-Pinkham, Sorkin, and Swift (2020) amongst others have shown, this is essentially a difference-in-difference (DID) identification strategy, resting on an underlying assumption that levels of base year shares in specific regions were uncorrelated with the subsequent growth in these shares. To illustrate what this assumption means: the growth of the IT sector in Bengaluru until 1990 was driven by local policy/infrastructure factors (such as government R&D investments) that played no subsequent role in the growth of this sector after 1998 (besides its role in increasing the exposure of Bengaluru to the post-1998 surge in global demand for outsourcing of IT services).

However, the exact instrument used by the authors appears to deviate from a classic Bartik instrument, insofar as they use lagged employment shares rather than shares in a base period (see Equation (4) in the paper). This means that the growth in the instrument incorporates growth in lagged employment shares. This quasi-Bartik instrument then requires a more demanding assumption: that current growth rates of specific traded services are uncorrelated with lagged growth rates. In other words, every seven years, there is an entirely new and independent source of global trade or technology shock that provides the underlying growth stimulus. It would be useful to see how robust the results would be if they were to revert to the standard Bartik instrument, e.g., where they use the 1990 employment shares as weights through all succeeding periods.

As Goldsmith-Pinkham, Sorkin and Swift (2020) urge, the Bartik instrument should be subjected to a variety of plausibility and robustness checks. For instance, a variance decomposition of the instrument would reveal what the

bulk of the changes in the instrument are driven by external shocks rather than the internal weights. The authors could check whether pre-1998 growth rates were uncorrelated with levels of the 1998 employment shares, as required by the underlying assumption of parallel pre-trends. The most demanding robustness check would involve an over-identification test, given the multiplicity of underlying instruments (the employment shares of specific traded services): would dropping some of them would change the results materially.

Primary Results and Possible Supplemental Analyses

The scatterplot in Figure 2 shows a strong positive correlation of both the actual and predicted changes in traded services with corresponding changes in non-traded service employment. This figure helps convince us of a robust connection between district level growth in the two sets of sectors. And the subsequent regressions show this pattern remains robust to inclusion of time dummies, location dummies, and controls for education. Following these results which pertain to aggregate employment in the two sets of sectors, the authors examine heterogeneity of these effects across various sub-sectors in order to better understand the underlying channels of causation. The evidence indicates that demand (forward) linkages driven by income effects on consumer spending were the key, with little evidence of supply (backward) linkages. This is an important insight.

They also find evidence of benign distributive impacts, in favor of small firms employing less than ten workers, and those with women entrepreneurs and employees. It would be helpful to translate the estimates in terms of implied formal-informal employment multiplier: the number of non-traded jobs generated by one traded sector job.

I think there is scope for expanding the analysis of distributive implications in a variety of directions. First, the authors could explore impacts on households of varying levels of prosperity, e.g. as proxied by different deciles or quartiles of the household expenditure distribution. Moreover, they could examine the role of local inequality in the multiplier process e.g., if the marginal propensity to spend is higher among poorer groups then districts with lower inequality would be associated with a higher multiplier.

Finally, they could use the labor force surveys of the NSS to examine whether the employment generated in the non-traded sector was associated with particularly low wages and productivity. This is necessary to address the concern that the non-traded sector employment generated did not correspond to much wage growth in the economy.

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General Discussion

The discussion was initiated by Arvind Panagariya, who asked if 'good jobs' were being created in the services sector to tackle unemployment. There is sufficient National Sample Survey (NSS) data to support research on this issue. The Chair, Indermit Gill, averred that as a labor economist, he perceived the term 'good jobs' as an ambivalent concept as it ostensibly focuses only on wages whereas there is a need to consider productivity too, and it is important to create services jobs that are both inclusive and ensure high productivity. However, in view of the large size of the services sector, some jobs in it could focus on productivity while others could ensure inclusiveness. In this context, there is a need to assess the relationship and analyse the complementarity between tradable and non-tradable jobs.

Anup Malani asked that since the paper has indicated a higher employment of females in the services sector, does this also reflect income inequality? It would be interesting to characterize households by income and examine how household income is related to employment in services, that is, whether the rich tend to work in the services sector more than those with lesser household incomes. Further, if there is a self-limiting effect on income inequality in services sector employment, how much of this is on the intensive or extensive margins in terms of the number of jobs, reflected in the creation of a higher number of jobs but a proliferation of low-wage jobs?

Prachi Mishra said that Economic Surveys in the past have shown that 80-90 percent of the population is engaged in jobs characterized by low productivity whereas the high-productivity jobs in the services sector employ a very small proportion of the population. It would thus be advisable to regurgitate these findings in research and highlight the concomitant variations in productivity.

Rana Hasan highlighted the need to look at the change in the firm size of distribution, to determine if the employers in the non-tradable sector are going

from two or three-size establishments to say ten-plus establishments, which could be an indicator of growth in productivity.

Surjit Bhalla endorsed the comments of both the discussants, and also cited some ballpark figures for the kinds of jobs available in the services sector in India. According to the Periodic Labour Force Survey (PLFS), 25 percent of the jobs are salaried jobs, 25 percent are casual worker jobs, and the remaining 50 percent of the workers are self-employed. It is difficult to estimate the wages of the self-employed firms and workers, and one can only get an idea of the total income of the family or the household. The PLFS is a rich source of data for salaried versus non-salaried workers, whereas the Consumer Pyramids Household Survey (CPHS) indicates that the proportion of female employment is much lower than that of male employment. It is important to determine and analyse these figures, which, in turn, will give rise to hypotheses that can be tested.

Sudipto Mundle remarked that the PLFS data can be supplemented by high-frequency data from the Centre for Monitoring Indian Economy (CMIE), and the two databases can also be compared to arrive at unemployment and wage rates for the sector. There are huge islands of very high-paying jobs that are spreading mainly through the demand channel to very low-paid jobs, which can be captured by using the PLFS data in conjunction with the CMIE data.

Ruchir Agarwal pointed to the need for producing welfare-relevant metrics, especially for quantifying the differential wages for different levels of jobs. Moreover, one must determine how far migration of workers is responsible for both job creation and job displacement in the sector.

Sam Asher noted the huge frictions associated with migration in India and stressed the need for more work on this issue. It is well known that there is extensive migration across the country, that is, 15 percent of the men in the active workforce migrate for work over the course of their lifetime. In the context of concentrated growth, this incidence of large and persistent migration is a pointer for equalizing wages across space. However, the time horizon for migration is critical. There may not be much migration in the short-run but over the long-run, a bunch of laborers are going to flow out, and wages would consequently shoot up with an increase in the demand for labor.

Indermit Gill concluded the discussion by flagging the high-productivity features of the services sector, which makes it more inclusive relative to both agriculture and manufacturing. This also implies that the sector can be more female labor-intensive as well as spatially more inclusive as compared to the other higher-productivity activities. Another feature is that services can also be tradable and the paper aptly defines tradability relative to manufacturing, especially because we think of manufactured goods as completely tradable. Thus, we can ensure a finer distribution of services, essentially those associated with transport, tourism, and technology, among other things.

We also need to explore whether or not the advent of new technologies can facilitate greater inclusiveness in employment in the services sector. Even if these technologies are applied at the high end, their benefits accrue to the lower end of the employment spectrum in services. It would also be interesting to examine which sectors within tradable services would drive business growth. Services-led growth can be more inclusive and can augment productivity. There is a high degree of complementarity between tradable and non-tradable services. Hence, the higher productivity part of services may actually represent a smaller share of total employment, but favorable policies can lead to growth in those services and can also have positive spillover effects, making the sector more spatially and socially inclusive. Further, breaking down 'good jobs' in terms of skills and wages would be a meaningful and rigorous way of assessing the productivity of jobs. It would also aid in devising a services-led development strategy, and in the creation of more 'quality' jobs. Policy for the sector should therefore take into account varied issues, including backward and forward linkages, and consumption-related spillovers versus supply-side spillovers.

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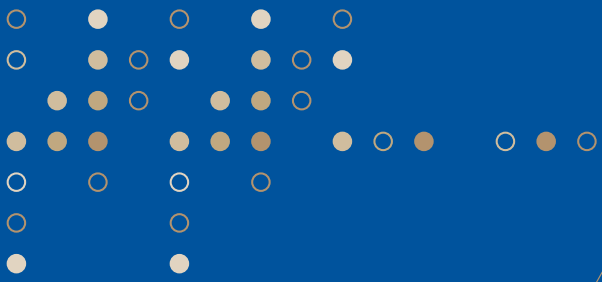

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ISBN 978-93-327-0619-4