Shortages of water and land, deterioration in soil quality, and of course climate change-induced temperature increases and rainfall variability, are all going to impact agriculture. It is therefore opportune to analyze the effects of climate on Indian agriculture.

Why Agriculture Matters: An Irony

6.3 First, and foremost, agriculture matters in India for deep reasons, not least because the farmer holds a special place in Indian hearts and minds. The first salvo of satyagraha was fired by Mahatma Gandhi on behalf of farmers, the indigo farmers exploited by colonial rule. Not unlike in early, Jeffersonian America (Hofstadter, 1955), history and literature have contributed to the farmer acquiring mythic status in Indian lore: innocent, unsullied, hard-working, in harmony with nature; and yet poor, vulnerable, and the victim, first of the imperial masters and then of indigenous landlords and middlemen. Bollywood (and Kollywood and Tollywood) has also played a key role in creating and reinforcing the mythology of the Indian farmer (for example, in movies such as *Mother India, Do Beegha Zameen, Upkaar*, *Lagaan*, and more recently *Peepli Live*).

6.4 Agriculture also matters for economic reasons because it still accounts for a substantial part of GDP (16 percent) and employment (49 percent)[1]. Poor agricultural performance can lead to inflation, farmer distress and unrest, and larger political and social disaffection—all of which can hold back the economy.

6.5 The Nobel Prize winner, Sir Arthur Lewis (among others), argued that economic development is always and everywhere about getting people out of agriculture and of agriculture becoming over time a less important part of the economy (not in absolute terms but as a share of GDP and employment). The reason why agriculture cannot be the dominant, permanent source of livelihood is its productivity *level*, and hence the living standards it sustains, can never approach—and have historically never approached—those in manufacturing and services. That, of course, means that industrialization and urbanization must provide those higher productivity alternatives to agriculture. But this must happen along with, and in the context of, rapid productivity growth in agriculture, to produce greater food supplies for the people, provide rising farm incomes, and permit the accumulation of human capital.

6.6 At the same time, Dr. Ambedkar warned about the dangers of romanticizing rural India. He famously derided the village as "a sink of localism, a den of ignorance, narrow mindedness and communalism," thereby expressing a deeper truth—an Indian social complement to the Lewisian economic insight—that in the long run people need to move and be moved out of agriculture for non-economic reasons.

6.7 So the irony is that the concern about farmers and agriculture today is to ensure that tomorrow there are fewer farmers and farms but more productive ones. In other words, all good and successful economic and social development is about facilitating this transition in the context of a prosperous agriculture and of rising productivity in agriculture because that will also facilitate good urbanization and rising productivity in other sectors of the economy.

Long run agricultural performance

6.8 The focus on agriculture is warranted by its long run economic performance. Chand (2012) and Gulati (2009), among others have analysed the temporal and spatial performance of agriculture. Real agricultural growth since 1960 has averaged about 2.8 percent in India. The period before

[1] The International Labour Organization (ILO) estimates the agriculture share of employment at 44.3 percent.

the Green Revolution saw growth of less than 2 percent; the following period until 2004 yielded growth of 3 percent; in the period after the global agricultural commodity surge, growth increased to 3.6 percent (Figure 1). China's annual agricultural growth over the long run has exceeded that of India by a substantial 1.5 percentage points on average.

6.9 The volatility of agricultural growth in India has declined substantially over time: from a standard deviation of 6.3 percent between 1960 and 2004 to 2.9 percent since 2004. In particular, production of cereals has become more robust to drought.

6.10 But levels of volatility continue to be high and substantially higher than in China where the ups and downs have been virtually eliminated (Figure 2, circled area). An important contributing factor is that agriculture in India even today continues to be vulnerable to the vagaries of weather because close to 52 percent (73.2 million hectares area of 141.4 million hectares net sown area) of it is still un-irrigated and rainfed.[2]

6.11 Against this background, this chapter pursues three objectives - first, to document the changes in climactic patterns in temperature and rainfall over the past six decades.[3] Second, to estimate the effects of fluctuations in weather on agricultural productivity. And finally, to use these short-run estimates in conjunction with predicted changes in climate over the long-run to arrive at estimates of the impact of global warming on Indian agriculture. A number of distinguished Indian agricultural economists have analysed various aspects of agriculture [Chand (2007, 2010, 2012 2015), Gulati (1999, 2005, 2007, 2008, 2009, 2017), Ramaswami (2001, 2002, 2013), Swaminathan (2005, 2008, 2010)] but there have not been recent estimates of the impact of weather on agriculture at such a disaggregated level.

Motivation

6.12 But why re-invent the wheel, when there already is a burgeoning and serious body of research and analysis at the international level of the impact of climate on economic activity Deschênes, and Greenstone (2007 and 2011); Dell, Jones and Olken (2012 and 2014); IMF (2017); and Burke, Hsiang, and Miguel (2015)?

6.13 The answer is threefold. There is the standard worry that cross-country analysis might not apply to large, individual countries such as India, which is agrarian and is home to a great diversity of climate zones. A second, related point is that an India-specific analysis would be more granular, done at a spatially more disaggregated level than coarser cross-country analysis (although there are cross-country analysis that use such disaggregated data).

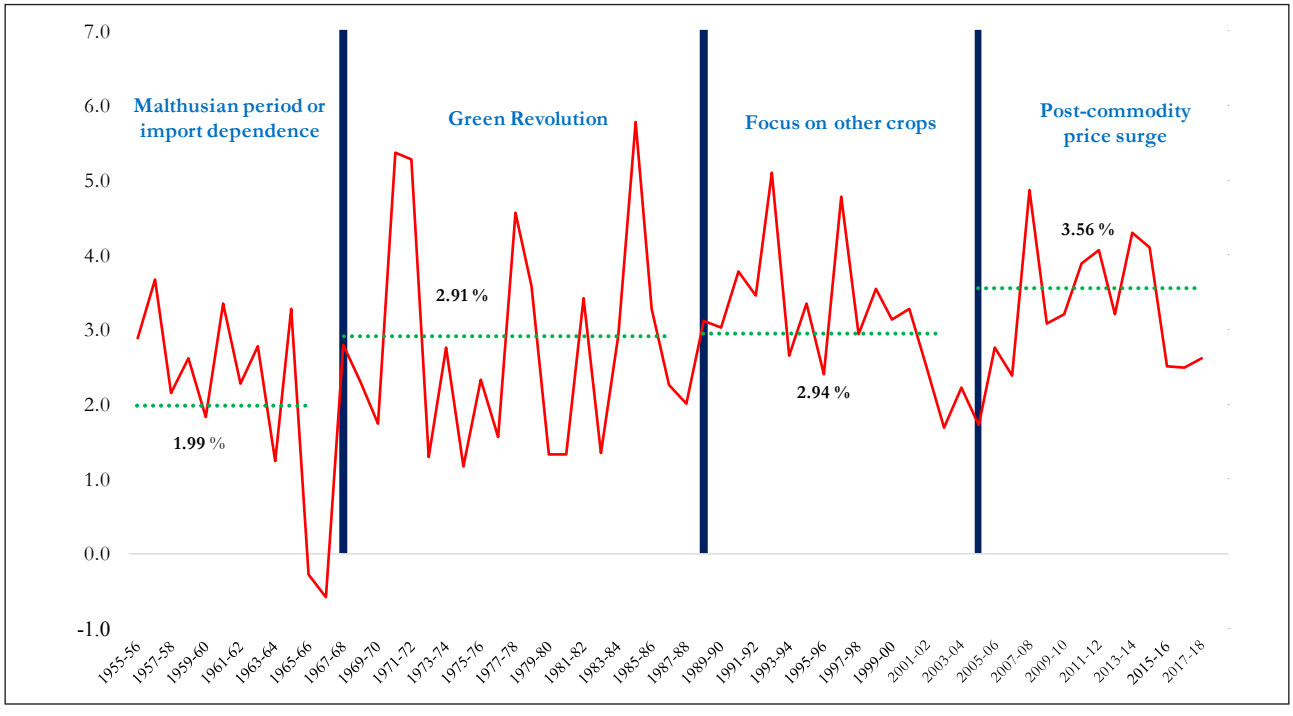
6.14 A final and important reason—with implications for research findings and hence policy input—has to do with data quality. Nearly all the available cross-country analysis use cross-country databases on temperature, weather, and extreme events. For example, Dell, Jones and Olken (2012, 2014) and IMF (2017) use a dataset created by the University of Delaware for temperature and precipitation. These databases rely on Indian data but with far fewer actual measurement points ("stations") than available with the Indian Meteorological Department (IMD). The Delaware

[2] Annual Report, 2016-17, Ministry of Agriculture & Farmers Welfare.

[3] Throughout this chapter, "weather" is used to refer to annual realizations of temperature and precipitation, whereas "climate" refers to long-term patterns in these variables.

Figure 1. Real Agricultural GVA Growth in India, 1960-2016

(in percent, 5 year moving average)

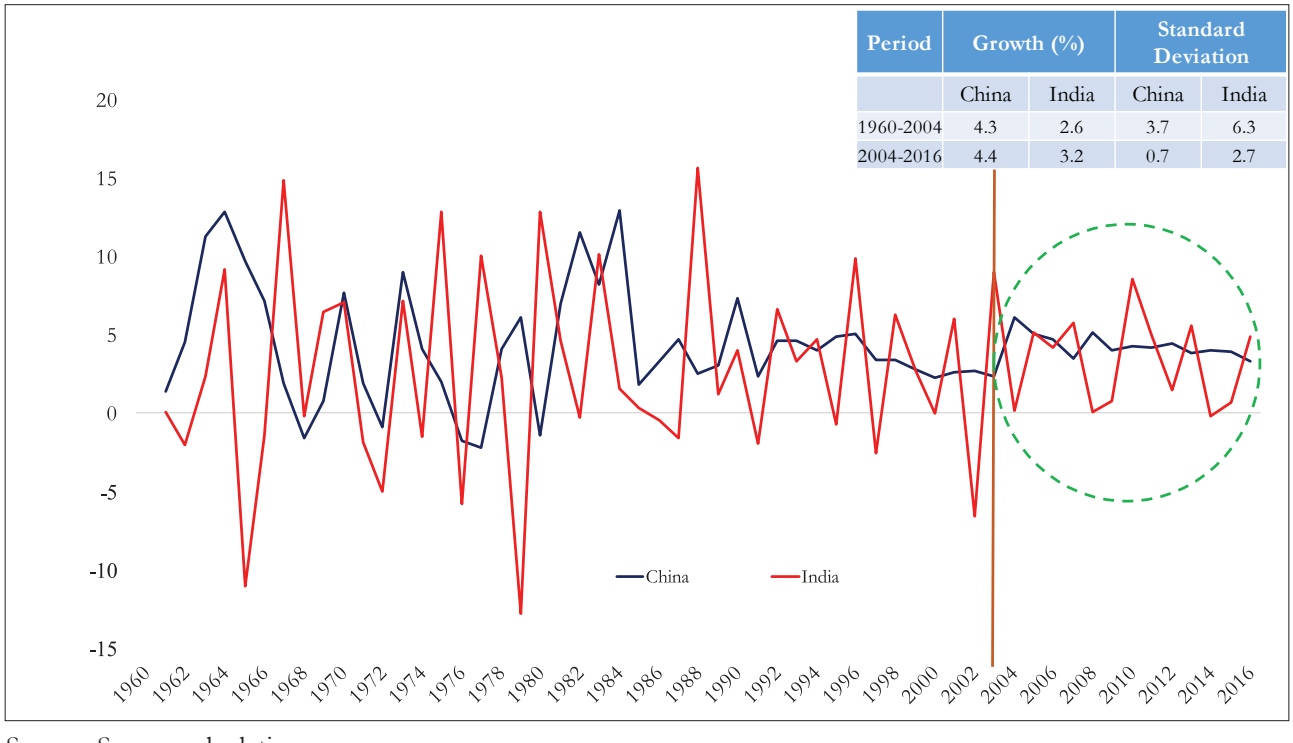


Source: Survey calculations.

Note: Numbers represent average agricultural growth rates for each period in percent.

Figure 2. Real Agricultural GDP Growth, China and India, 1960-2016

(in percent)



Source: Survey calculations.

Figure 3. Temperature and Rainfall : Comparison of Indian & International Data

Figure 3a. Average Annual Temperature

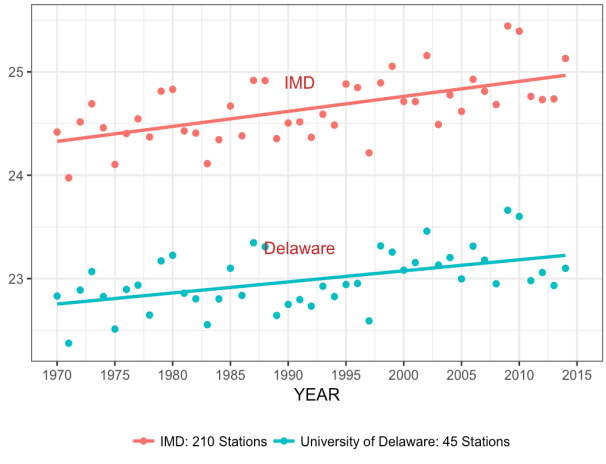
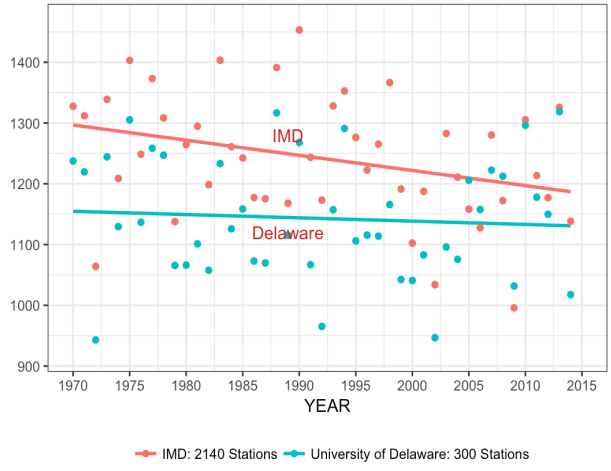


Figure 3b. Average Annual Rainfall



Source: Survey calculations from IMD and University of Delaware data. For temperature, the annual average is estimated for each grid point, and then averaged across all grid points to obtain the all-India average. For rainfall, the total rainfall for each grid point is averaged across all grid points to obtain the all-India average.

temperature data base is gridded (to make it spatially representative) but based on 45 weather stations in India whereas the IMD data is gridded from 210 weather stations. Similarly, the Delaware database for precipitation relies on Indian rainfall data provided by 300 stations compared to an actual sample of 2140 stations (See Annex for a comparison of Indian and cross-country databases).

6.15 The divergences between the cross-country databases are illustrated in Figures 3a and 3b below for the average annual temperature and average annual rainfall data, respectively.[4]

6.16 In these figures, there are substantial differences in both levels and trends between the two datasets. For example, IMD data (in red) record much higher average[5] levels of temperatures than the Delaware dataset (by over 1 degree Celsius on average, in climate terms, the difference between disaster and nirvana). Similarly, the IMD data shows higher levels of precipitation of about 100 millimetres on average (again a potential difference between deluge and drought) with a sharply declining trend since the 1970s unlike the Delaware data. These differences suggest that any analysis of long run climate impacts could be very different across these datasets.

6.17 Thus, armed with high quality, high resolution, temperature and precipitation data, this chapter proceeds to analyze patterns in temperature and precipitation in India, and the impact they have on agricultural productivity.

TEMPORAL AND SPATIAL PATTERNS OF TEMPERATURE AND PRECIPITATION

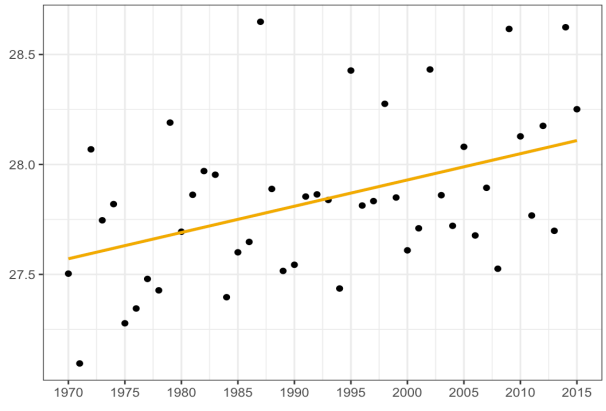
6.18 Figure 4 plots average temperature by cropping seasons. The broad pattern of rising temperatures post 1970s is common to both seasons. The average increase in temperature between the most recent decade and the 1970s is

[4] Averages calculated over all grid points of Delaware and IMD datasets, which lie within the boundaries of India.

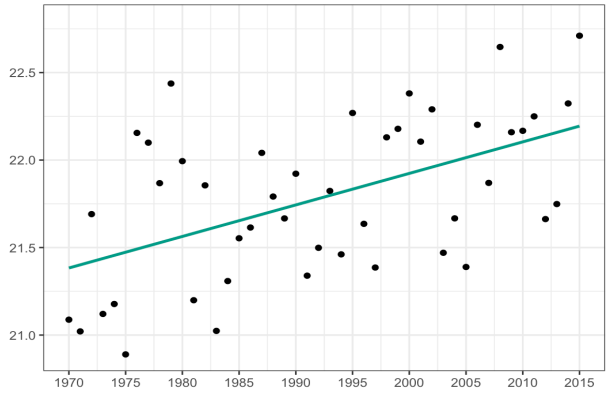
[5] So, the differences between the two databases could arise for two reasons: daily (IMD) versus monthly (Delaware) and 210/2140 (IMD) versus 45/300 (Delaware) collections points for temperature/rainfall. IMD datasets are more detailed and disaggregated.

Figure 4. Average Temperature by Cropping Season: Kharif and Rabi
(degrees Celsius)

Kharif



Rabi



Source: Survey calculations from IMD data.

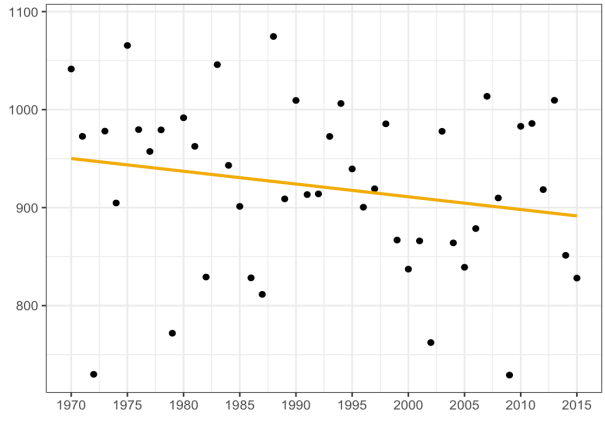
about 0.45 degrees and 0.63 degrees in the kharif and rabi seasons, respectively. These trends are consistent with those reported in Rajeevan (2013).

6.19 Figure 5 plots the rainfall patterns in the two seasons. Between the 1970s and the last decade, kharif rainfall has declined on average by 26 millimeters and rabi rainfall by 33 millimeters. Annual average rainfall for this period has on average declined by about 86 millimeters.

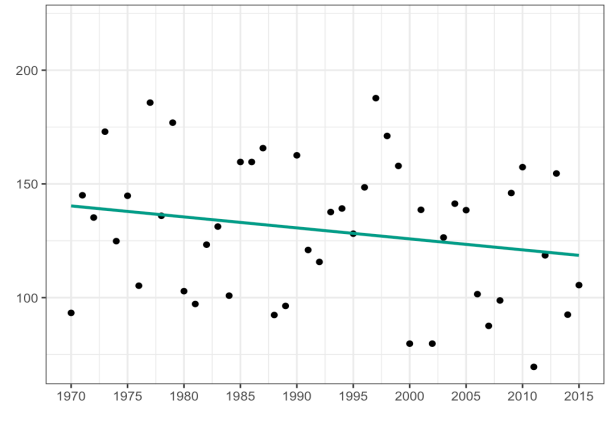
6.20 What about the number of days with extremely high and low temperatures? Figure 6 plots the proportion of days during the monsoon season in each year when the temperature was extremely high (defined as greater than the 95th percentile of the grid-point specific temperature distribution) and extremely low (less than the 5th percentile of the grid point specific temperature distribution). These figures are suggestive of a rise in the number of days with extremely high temperatures, and a corresponding decline in the number of days with low temperatures.

Figure 5. Average Precipitation by Cropping Season: Kharif and Rabi
(Millimetres)

Kharif

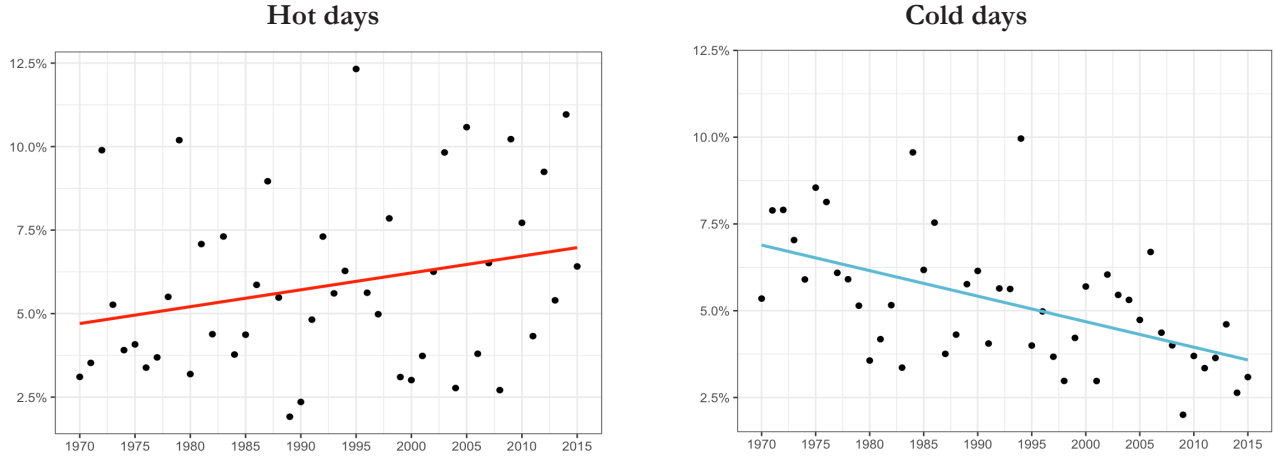


Rabi



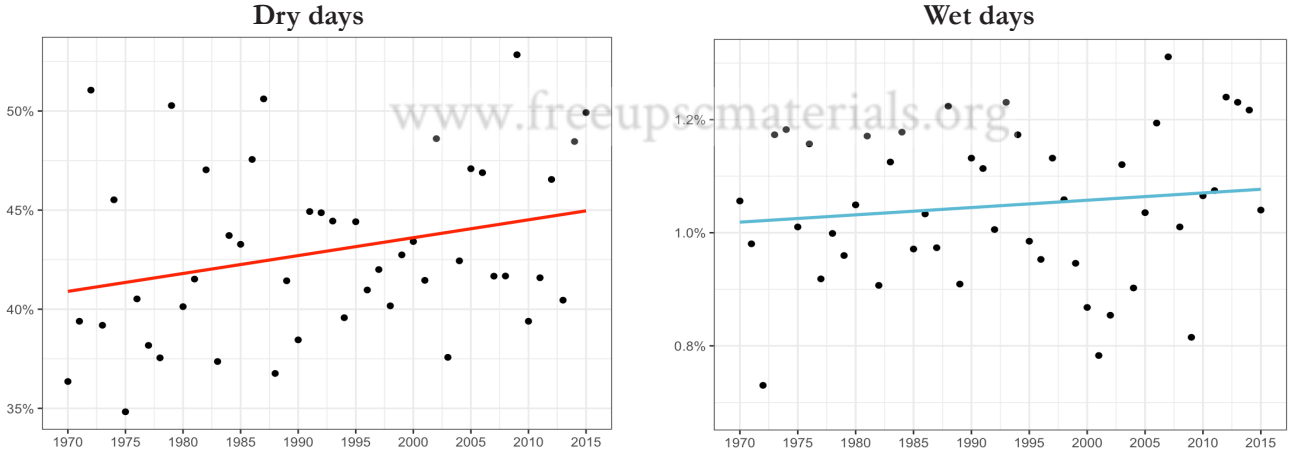
Source: Survey calculations from IMD data.

Figure 6. Very Hot and Cold Days during the Monsoon
(percentage of total days)



Source: Survey calculations from IMD data.

Figure 7. Dry and Wet Days during the Monsoon
(percentage of total days)

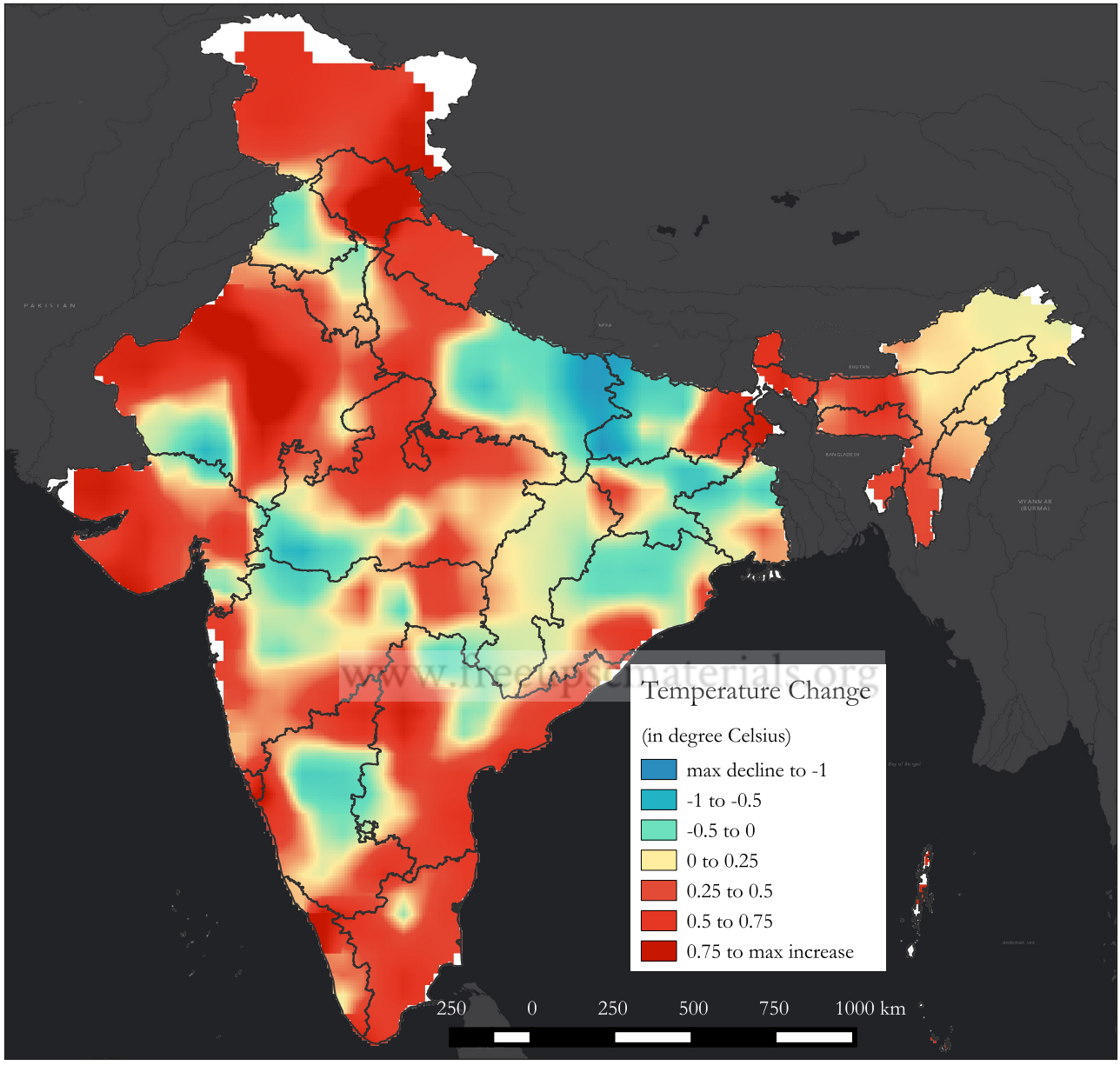


Source: Survey calculations from IMD data.

6.21 Turning attention to rainfall extremities, Figure 7 shows that the proportion of dry days (rainfall less than 0.1 mm per day), as well as wet days (rainfall greater than 80 mm per day) has increased steadily over time. Thus, the imprint of climate change is clearly manifest in the increasing frequency of extreme weather outcomes.

6.22 The spatial dimensions of changes in weather are displayed in Figure 8a (for temperature) and Figure 8b (for rainfall). They show, respectively, the difference in temperature and rainfall between the last decade (2005-2015) and the period 1950-1980. Figure 8a illustrates the pattern of average warming with a large part of the map covered in red. Temperature increases have been particularly felt in the North-East, Kerala, Tamil Nadu, Kerala, Rajasthan and Gujarat. Parts of India, for example, Punjab, Odisha and Uttar Pradesh have been the least affected. In contrast, Figure 8b indicates that extreme deficiencies are more concentrated in Uttar Pradesh, North-East, and Kerala, Chattisgarh and Jharkhand. There

Figure 8a. Spatial Changes in Temperature
(change in average temperature between the last decade and 1950-1980 period)



Source: Survey calculations from IMD data.[6] Red (blue) denotes rising (falling) temperature.

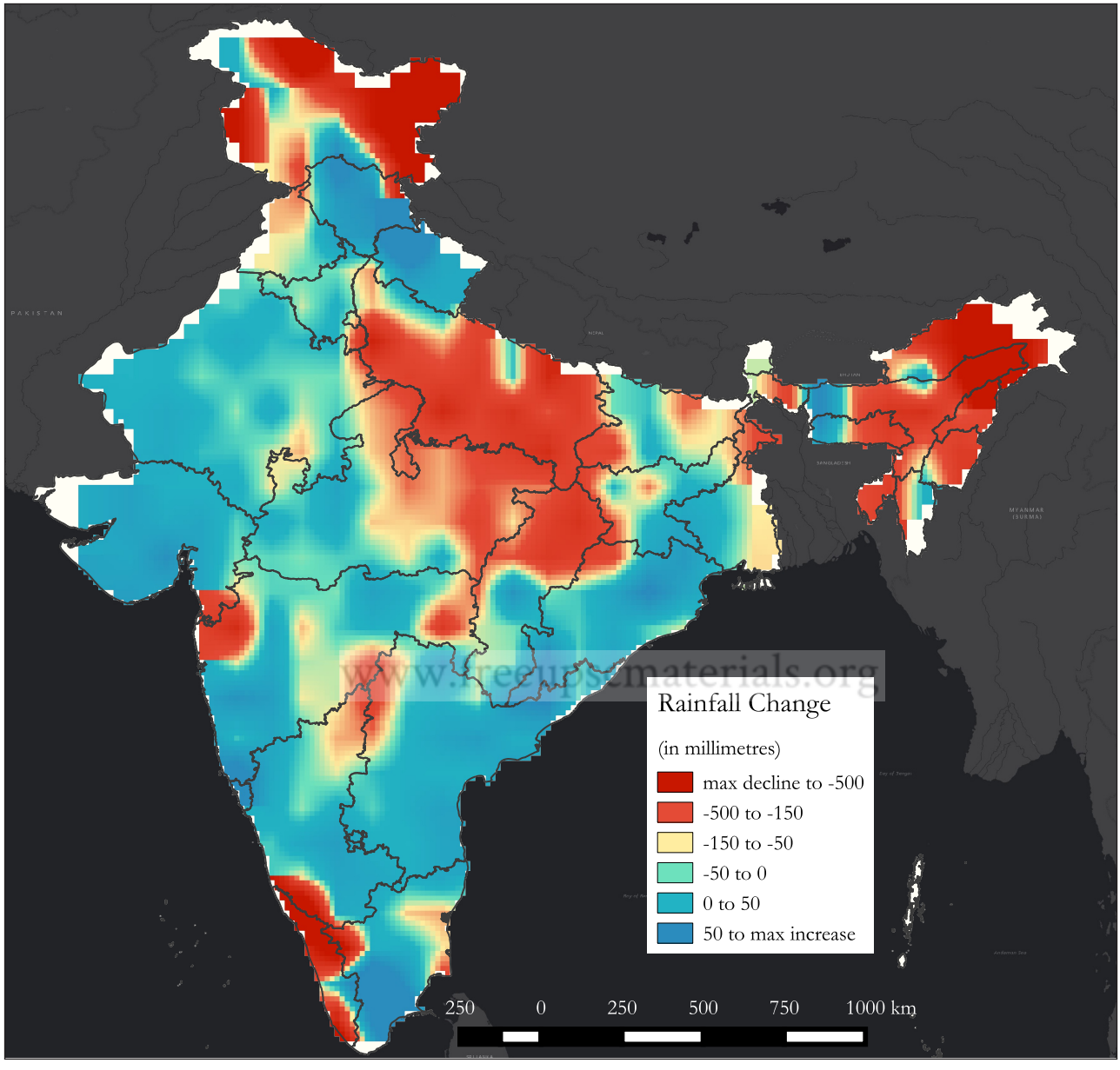
has actually been an increase in precipitation in Gujarat and Odisha and also Andhra Pradesh. What is interesting is that spatially temperature increases and rainfall declines seem to be weakly correlated.

IMPACT OF WEATHER ON AGRICULTURAL PRODUCTIVITY

6.23 Estimating the impact of temperature and climate on agriculture has become an increasing focus of economic research. Many of the

[6] Grid point weather data (1 degree grid for rainfall and 0.5 degree grid for temperature) was converted to raster and further disaggregated (using bilinear smoothening). Areas in white represent missing grids.

Figure 8b. Spatial Changes in Rainfall
(change in average rainfall between the last decade and 1950-1980 period)



Source: Survey calculations from IMD data. Red (blue) denotes decreasing (increasing) rainfall.

concerns relate to developing countries because climate impacts seem to be either present only or disproportionately, in hotter and less rich parts of the world (IMF, 2017; Dell, Jones and Olken, 2012).

6.24 This chapter uses disaggregated data at the district level—on temperature, weather, and crop production, yields, and prices —to answer a number of important questions.[7] The analysis is conducted for the cropping seasons of kharif

[7] The impacts of CO^2 emissions and water transpiration have not been factored because of data limitations.

and rabi separately. A few main findings, supported by charts and tables, are highlighted here while the details of the methodology used and the regression analysis are discussed in the Annex.

Stark heterogeneity: Extreme versus Moderate shocks; Irrigated versus Unirrigated Areas

6.25 The present analysis yields two key findings. The first—and one with significant implications in the context of looming climate changes—is that the impact of temperature and rainfall is highly non-linear and felt almost only when temperature increases and rainfall shortfalls are extreme. The second is that these extreme shocks have highly divergent effects between unirrigated and irrigated areas (and consequently between crops that are dependent on rainfall), almost twice as high in the former compared with the latter.

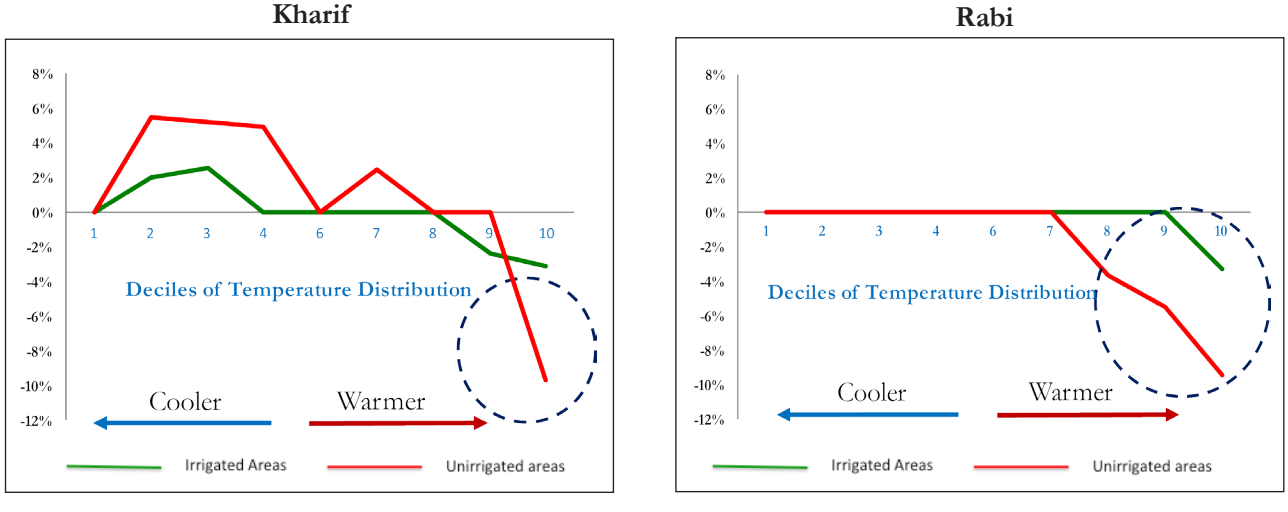
6.26 These findings are first illustrated graphically. In Figures 9 and 10, the x-axis depicts deciles of temperature and rainfall, with the 5th decile being the middle category (normal temperature and rainfall) against which all comparisons are made. So, consider the left panel of Figure 9: if temperature was in the 10th decile of the temperature distribution (i.e. the hottest possible), kharif yields in unirrigated areas (the red line) would be 10 percent lower than if temperature was normal, i.e. in the 5th decile.

6.27 Similarly, the left panel of Figure 10 shows that if rainfall were in the 1st decile (cases of drought and drought-like conditions), kharif yields would be 18 percent lower in unirrigated areas than if rainfall was normal (i.e in the 5th decile).

6.28 The first key finding that only high temperature shocks matter is reflected in the fact that the red line in the temperature graphs in Figure 9 (both panels) is very close to the x-axis for nearly the entire part of the distribution except toward the right corner. That is, under any condition of less-than-extreme heat, the impact is close to zero, and it is as if temperature is normal. Similarly, the fact that only extreme rainfall shortages matter is reflected in the fact that the red line in the rainfall graphs in Figure 10 is close to the x-axis except towards the left extreme.

6.29 A large literature focuses on the impact of a one-unit increase in temperature and a one unit decrease in rainfall on agricultural yields (e.g Dell, Jones and Olken 2012). The analysis in this chapter suggests that in the Indian context, such marginal changes in weather have little or no

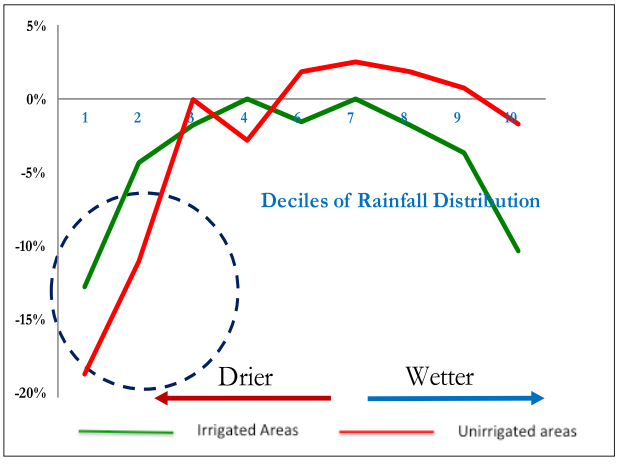
Figure 9. Effects of Temperature on Yields



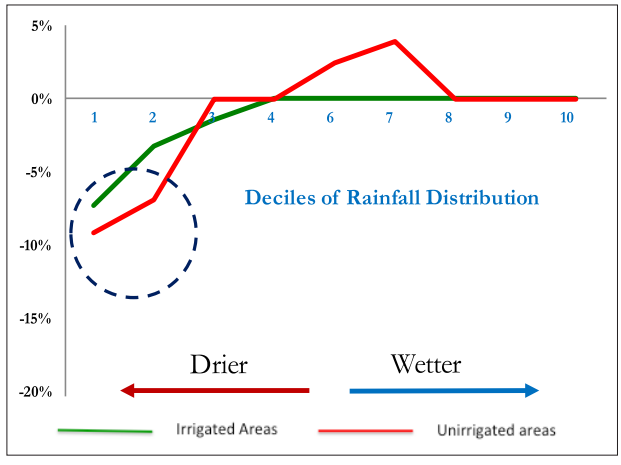
Source: Survey calculations from IMD and ICRISAT data.

Figure 10 : Effects of Rainfall on Yields

Kharif



Rabi



Source: Survey calculations from IMD and ICRISAT data.

impact, and that the adverse effects of weather are concentrated in the extremes. These findings have important implications for the impact of climate change on agriculture (discussed later in this chapter), since most climate change models predict an increase in extreme weather events.

6.30 The second key finding that these shocks have a much greater effect on unirrigated areas compared to irrigated areas is reflected in the fact that in all panels of Figures 9 and 10, the green line (showing the impact on irrigated areas) tend to be closer to the x-axis (of zero impact) than the corresponding red lines.[8]

6.31 Table 1 provides a detailed quantitative break-up of the effects of temperature and rainfall shocks between irrigated and unirrigated areas in the kharif and rabi seasons. Using the insights gained from figures 9 and 10, the quantitative impact of extreme shocks on yields and revenues is estimated. Extreme temperature shocks, when a district is significantly hotter than usual (in the top 20 percentiles of the district-specific temperature distribution), results in a 4 percent decline in agricultural yields during the kharif season and a 4.7 percent decline in rabi yields.[9] Similarly, extreme rainfall shocks - when it rains significantly less than usual (bottom 20 percentiles of the district-specific rainfall distribution). The result is a 12.8 percent decline in kharif yields, and a smaller, but not insignificant decline of 6.7 percent in rabi yields.

Table 1. Impact of Weather Shocks on Agricultural Yields
(percentage decline in response to temperature increase and rainfall decrease)

	Extreme Temperature Shocks	Extreme Rainfall Shocks
Average Kharif	4.0%	12.8%
Kharif, Irrigated	2.7%	6.2%
Kharif, Unirrigated	7.0%	14.7%
Average Rabi	4.7%	6.7%
Rabi, Irrigated	3.0%	4.1%
Rabi, Unirrigated	7.6%	8.6%

Source: Survey calculations.

[8] The one exception seems to be when there is an extreme excess of rainfall which seems to have a larger negative effect in irrigated areas than unirrigated areas (see the red and green lines in the right extreme of Figure 10, left panel).

[9] Based on ICRISAT data, the kharif crops considered in the analysis here are: Rice, Maize, Sorghum, Pulses, Cotton, Groundnut, Pearl Millet, Finger Millet and Soya. The rabi crops are: Wheat, Barley, Chickpea, Linseed, and Rape and Mustard Seed.

6.32 Unirrigated areas – defined as districts where less than 50 percent of cropped area is irrigated -- bear the brunt of the vagaries of weather. For example, an extreme temperature shock in unirrigated areas reduces yields by 7 percent for kharif and 7.6 percent for rabi. Similarly, the effects of extreme rainfall shocks are 14.7 percent and 8.6 percent (for kharif and rabi, respectively) in unirrigated areas, much larger than the effects these shocks have in irrigated districts.

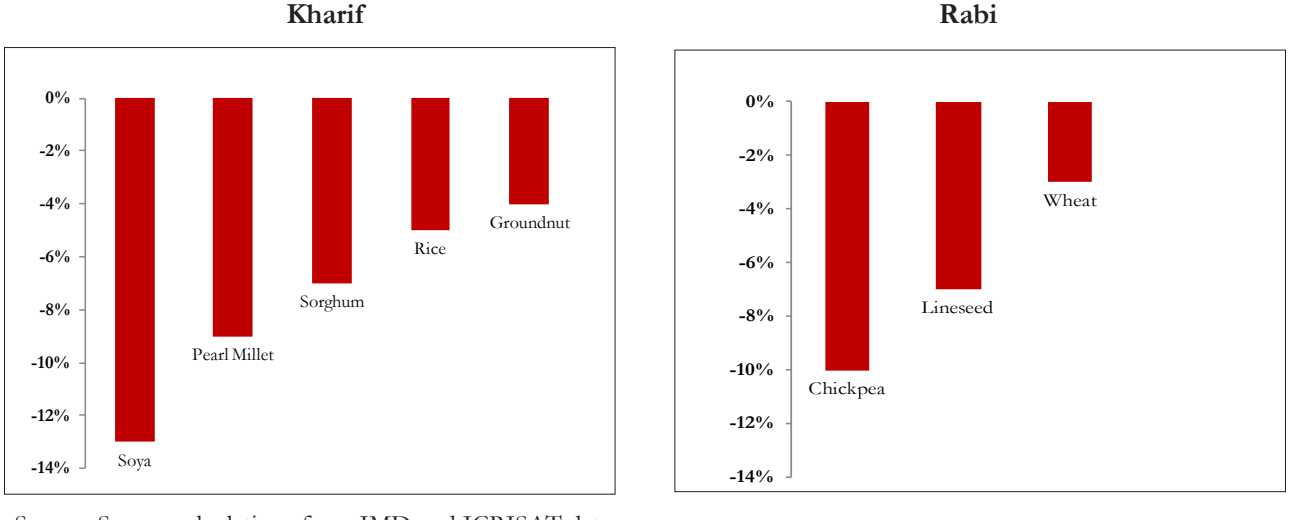
6.33 Finally, the literature suggests that several factors over and above the *level* of rainfall matter for agricultural yields. In particular, it matters *when* it rains. The data put together for this chapter makes it possible to explicitly test for these alternative channels. The results indicate that even after controlling for the level of rainfall, the number of dry days (defined as days during the monsoon with rainfall less than 0.1 millimetres) exerts a significant negative influence on productivity: holding the amount of rainfall constant, each additional dry day during the monsoon reduces yields by 0.2 percent on average and by 0.3 percent in unirrigated areas.

Crop impacts

6.34 A next finding relates to the varied susceptibility of different crops to temperature and precipitation. Figures 12 and 13 plot the effects of extreme temperature and rainfall shocks on the yields of individual crops[10]. The clear pattern that emerges is that crops grown in rainfed areas—pulses in both kharif and rabi—are vulnerable to weather shocks while the cereals—both rice and wheat—are relatively more immune.

6.35 Have the impacts changed over time? To answer this question, the analysis was redone by decade. In the last decade for which data is available (2004-2014), the impact of rainfall shocks in yields remains unchanged, but the effect of temperature shock increases threefold (relative to the first decade). However, since there is no secular trend in this impact, it cannot be ascertained whether the findings for the last decade are a one–off, or the start of a new long

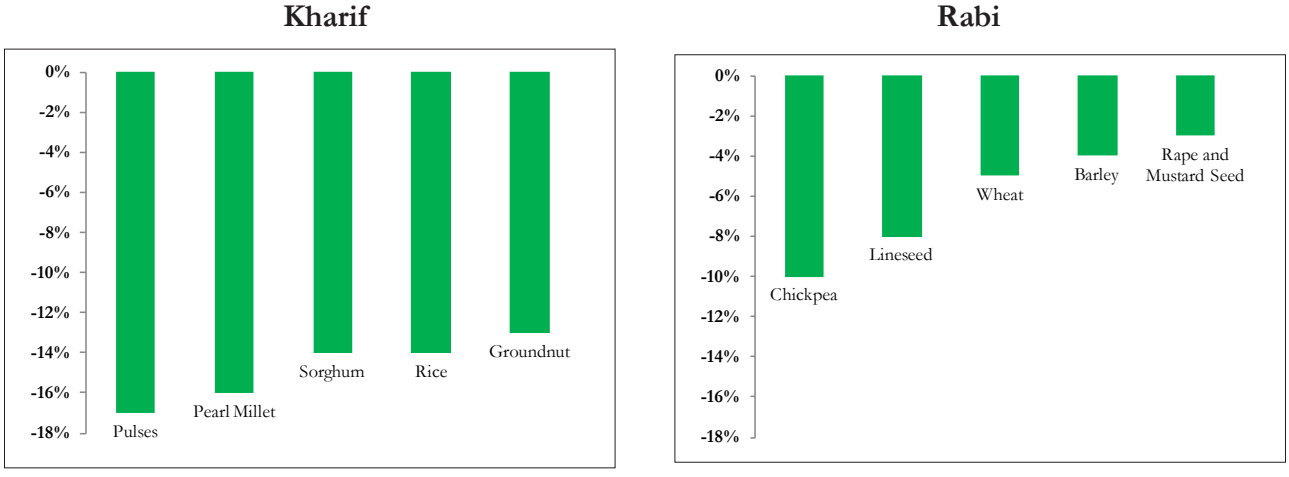
Figure 11. Effects of Extreme Temperature Increase on Crop Yields
(percentage decline)



Source: Survey calculations from IMD and ICRISAT data.

[10] These figures plot the coefficients on extreme temperature and extreme rainfall on individual crop level regressions. See Annex for a detailed description of the regression.

Figure 12. Effects of Extreme Rainfall Decrease on Crop Yields
(percentage decline)



Source: Survey calculations from IMD and ICRISAT data.

run trend with dramatically adverse consequences for Indian agriculture.[11]

IMPACT ON FARM REVENUE[12]

6.36 What do these numbers imply in terms of losses to farmers in the short and long run? Table 2 shows the impact of extreme shocks on famer incomes, measured by value of production.[13] Extreme temperature shocks reduce farmer incomes by 4.3 percent and 4.1 percent during kharif and rabi respectively, whereas extreme rainfall shocks reduce incomes by 13.7 percent and 5.5 percent. Once again, these average effects mask significant heterogeneity, with the largest adverse effects of weather shocks being felt in unirrigated areas. Ex-ante it is not clear which direction farm revenues should move in – on the one hand, these shocks reduce yields, but on the other, the lower supply should increase local prices. The results here clearly indicate that the "supply shock" dominates – reductions in yields lead to reduced revenues.

Table 2. Impact of Weather Shocks on Farm Revenue

	Extreme Temperature Shocks	Extreme Rainfall Shocks
Average Kharif	4.3%	13.7%
Kharif, , Irrigated	7.0%	7.0%
Kharif, Unirrigated	5.1%	14.3%
Average Rabi	4.1%	5.5%
Rabi, Irrigated	3.2%	4.0%
Rabi, Unirrigated	5.9%	6.6%

Source: Survey calculations from IMD & ICRISAT data.

6.37 Another way to present the result (not shown in Table 1) is as follows: In a year where temperatures are 1 degree Celsius higher farmer incomes would fall by 6.2 percent during the kharif season and 6 percent during rabi in unirrigated districts. Similarly, in a year when rainfall levels were 100 millimetres less than average, farmer incomes would fall by 15 percent during kharif and by 7 percent during the rabi season.

[11] The impact of extreme temperature shocks is also high in the first decade of our sample.
[12] Value of production is measured as the product of yields per hectare and prices. ICRISAT data do not have data on farm profits (revenues minus costs).
[13] When temperature is in the top 20 percentiles of the district-specific temperature distribution.

6.38 How do these estimates compare with those in the literature? Existing studies for India typically analyse the impact of weather shocks on the productivity of individual crops. For example, Swaminathan et. al. (2010) show that a 1 degree Celsius increase in temperature reduces wheat production by 4 to 5 percent, similar to the effects found here. Turning attention to international studies, Kurukulasuriya & Mendelsohn, (2008) find similar effects for 11 African countries – a one degree increase in temperature reduces revenues by 6 percent on average. A study by the IMF, (2017) finds that for emerging market economies a 1 degree Celsius increase in temperature would reduce agricultural growth by 1.7 percent, and a 100 millimetres reduction in rain would reduce growth by 0.35 percent. Since these are results on growth, they are not strictly comparable with the calculations in this chapter.

6.39 What do the numbers from Table 2 imply for the impact of climate change on agriculture performance in the long run? Climate change models, such as the ones developed by the Inter-governmental Panel on Climate Change (IPCC), predict that temperatures in India are likely to rise by 3-4 degree Celsius by the end of the 21st century (Pathak, Aggarwal and Singh, 2012). These predictions combined with our regression estimates imply that in the absence of any adaptation by farmers and any changes in policy (such as irrigation), farm incomes will be lower by around 12 percent on an average in the coming years. Unirrigated areas will be the most severely affected, with potential losses amounting to 18 percent of annual revenue.

6.40 Climate change models do not have unambiguous predictions on precipitation patterns, Rajeevan (2013). But if the observed decline in precipitation over the last three decades (of over 86 millimetres) is applied to the estimates, it is found that in unirrigated areas, farm incomes will decline by 12 percent for kharif crops, and 5.4 percent for rabi crops.

6.41 Finally, models of climate change also predict an increase in the variability of rainfall in the long-run, with a simultaneous increase in both the number of dry-days as well as days of very high rainfall. If the observed increase in the number of dry days over the past 4 decades are applied to the short-run estimates, this channel alone would imply a decrease in farm incomes by 1.2 percent.

6.42 Overall the analysis here suggests at least three main channels through which climate change would impact farm incomes – an increase in average temperatures, a decline in average rainfall and an increase in the number of dry-days. Of course, all three are likely to be correlated, and therefore the total impact of climate change will not be the simple sum of these individual effects.

6.43 To examine this potential correlation, Figure 13 plots differences in average temperature against differences in average rainfall for kharif, with the differences measured as the level in the most recent ten years (2005-2015) relative to first decade of the dataset (1950-80). The relationship is weakly negative both at state and weather station levels; at the state level the correlation is -0.30. What this suggests is that at least historically weather shocks have not offset each other, they may be mildly re-inforcing. If this holds true going forward, the three effects that are identified in this chapter could be mildly additive.

6.44 Taking these correlations into account, farmer income losses from climate change could be between 15 percent and 18 percent on average, rising to anywhere between 20 percent and 25 percent in unirrigated areas. These are stark findings, given the already low levels of incomes in agriculture in India. Even more worryingly, it is possible the estimates arrived at in this chapter might be lower than the true effects of climate change, given the potentially non-linear impact of future increases in temperature. The results in this chapter stand in contrast with similar studies both

Figure 13. Difference in Average Temperatures and Rainfall for kharif

Figure 13a. Major States

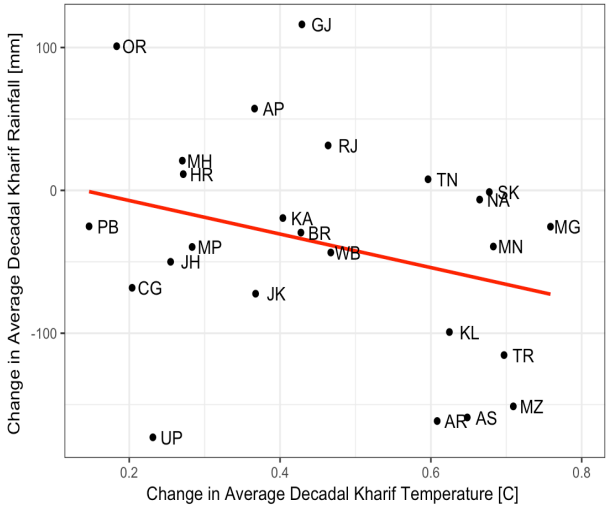
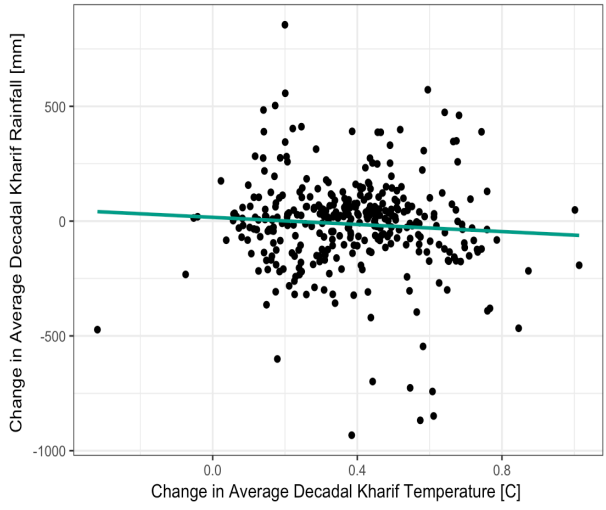


Figure 13b. Grid Points



Source: Survey calculations from IMD data.

Note: Excludes two potential outliers, Himacahal Pradesh and Uttarakhand.

globally and in India. For example, Deschenes and Greenstone (2007), find mild and even positive effects of climate change on agricultural profits in the United States. Kumar et al (2013) find that rice yields in unirrigated areas will only marginally be affected in the long run. Their estimates are based on climate change models that predict an increase in the average amount of rainfall.

6.45 At the same time, it is possible that these estimates overstate the true impact of climate change. The estimates in this chapter are derived using short-run variations in weather, and farmers may not be able to adapt to such fluctuations in the short-run. In the long-run, however, they may be able to change technologies or alter the crops they grow in response to sustained increases in temperature and changes in precipitation. Further it is possible that irrigation networks might expand, mitigating to some extent the adverse impacts of climate change.

CONCLUSIONS AND POLICY IMPLICATIONS[14]

6.46 Based on newly compiled weather data and a methodology that has not been applied to Indian data so far, this chapter estimated the impact of temperature and precipitation on agriculture. The main findings are as follows:

- A key finding—and one with significant implications as climate change looms—is that the impact of temperature and rainfall is felt only in the extreme; that is, when temperatures are much higher, rainfall significantly lower, and the number of "dry days" greater, than normal.
- A second key finding is that these impacts are significantly more adverse in unirrigated areas (and hence rainfed crops such as pulses) compared to irrigated areas (and hence crops such as cereals).
- Applying IPCC-predicted temperatures and projecting India's recent trends in precipitation, and assuming no policy responses, give rise to estimates for farm income losses of 15 percent to 18 percent

[14] In addition to the points noted below, there is a need to improve long term weather and crop forecasting and making them accessible to farmers and other relevant actors. For a recent example see TERI (2017).

on average, rising to 20 percent-25 percent for unirrigated areas. At current levels of farm income, that translates into more than Rs. 3,600 per year for the median farm household.

6.47 The policy implications are stark. India needs to spread irrigation – and do so against a backdrop of rising water scarcity and depleting groundwater resources. Figure 14 shows the increase in irrigation across time and space in India. In the 1960s, less than 20 percent of agriculture was irrigated; today this number is in the mid-40s. The Indo-Gangetic plain, and parts of Gujarat and Madhya Pradesh are well irrigated. But parts of Karnataka, Maharashtra, Madhya Pradesh, Rajasthan, Chattisgarh and Jharkhand are still extremely vulnerable to climate change on account of not being well irrigated.

6.48 The challenge is that the spread of irrigation will have to occur against a backdrop of extreme groundwater depletion, especially in North India. Figure 15a (Aeschbach, 2012) shows that India pumps more than twice as much groundwater as China or United States (Shah, 2008). Indeed global depletion is most alarming in North India (indicated by the "skyscrapers" in Figure 15a). Further analysis of groundwater stations reveals a 13 percent decline in the water table over the past 30 years, illustrated in Figure 15b.

6.49 Fully irrigating Indian agriculture, that too against the backdrop of water scarcity and limited efficiency in existing irrigation schemes, will be a defining challenge for the future. Technologies of drip irrigation, sprinklers, and water management—captured in the "more crop for every drop" campaign—may well hold the key to future Indian agriculture (Shah Committee Report, 2016; Gulati, 2005) and hence should be accorded greater priority in resource allocation. And, of course, the power subsidy needs to be replaced by

Figure 14. Spread of Irrigation over the Years

Figure 14a. Irrigated Proportion (1966)

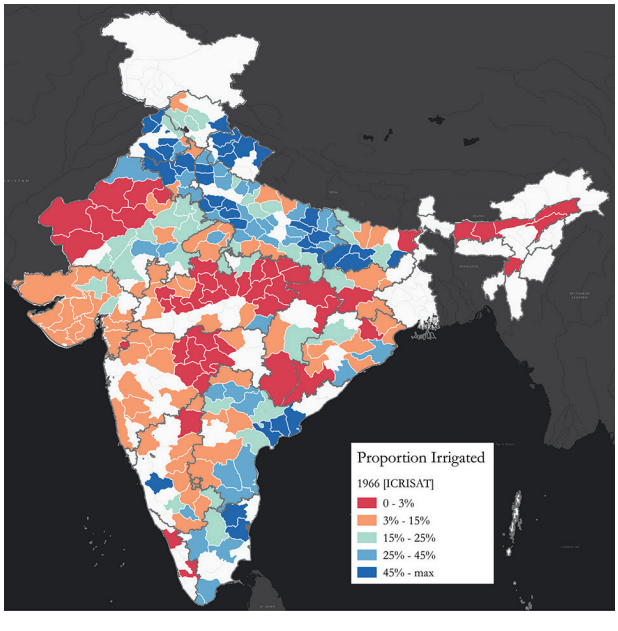
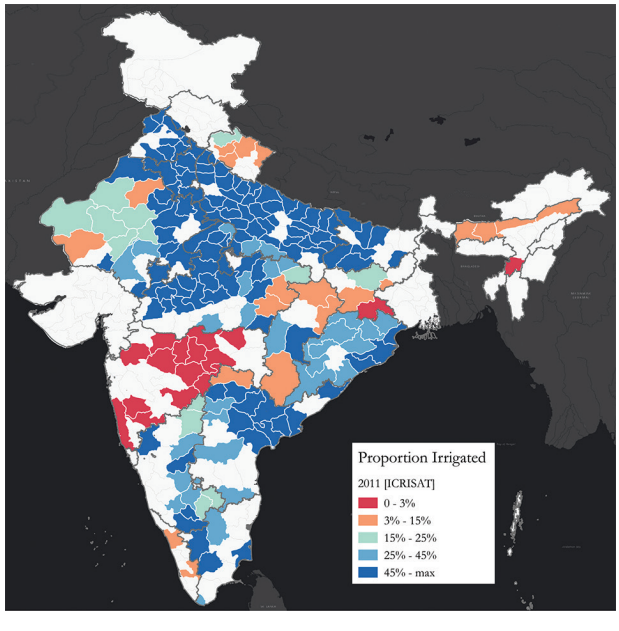


Figure 14b. Irrigated Proportion (2011)

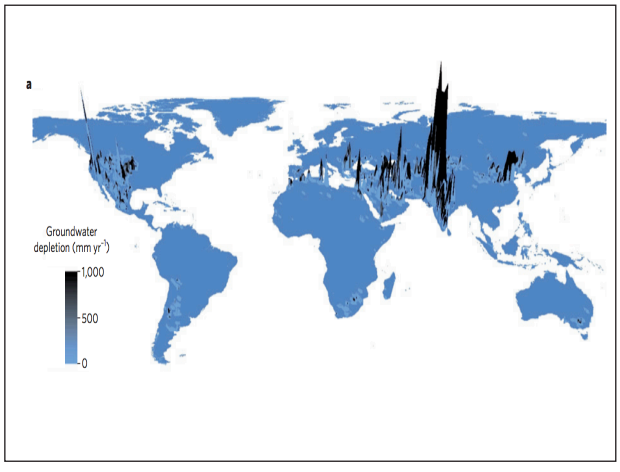


Source: Survey calculations from ICRISAT data.[15]

[15] Areas in white are missing in the ICRISAT database

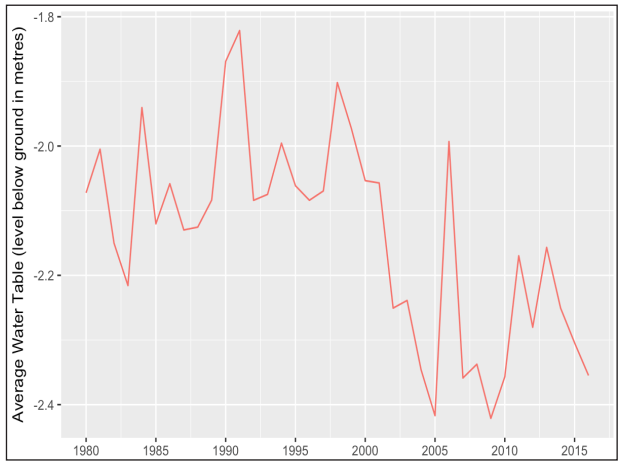
Figure 15. Groundwater Depletion

Figure 15a. World Depletion in Groundwater



Source: Aeschbach-Hertig, et al, 2012.

Figure 15b. Groundwater Depletion in India



Source: Survey calculations from Ministry of Water Resources data.

direct benefit transfers so that power use can be fully costed and water conservation furthered.

6.50 Another conclusion is the need to embrace agricultural science and technology with renewed ardor. Swaminathan (2010) urged that anticipatory research be undertaken to pre-empt the adverse impact of a rise in mean temperature. Agricultural research will be vital in increasing yields but also in increasing reliance to all the pathologies that climate change threatens to bring in its wake: extreme heat and precipitation, pests, and crop disease. The analysis shows that research will be especially important for crops such as pulses and soyabean that are most vulnerable to weather and climate.

6.51 Of course, climate change will increase farmer uncertainty, necessitating effective insurance. Building on the current crop insurance program (Pradhan Mantri Fasal Bima Yojana), weather-based models and technology (drones for example) need to be used to determine losses and compensate farmers within weeks (Kenya does it in a few days).

6.52 While the findings in this chapter are stark, they re-inforce a larger policy message on agriculture, elaborated in Subramanian (2017). In thinking about agricultural policy reforms in India, it is vital to make a clear distinction between two agricultures in India. There is an agriculture—the well-irrigated, input-addled, and price-and-procurement-supported cereals grown in Northern India—where the challenge is for policy to change the form of the very generous support from prices and subsidies to less damaging support in the form of direct benefit transfers.

6.53 Then there is another agriculture (broadly, non-cereals in central, western and southern India) where the problems are very different: inadequate irrigation, continued rain dependence, ineffective procurement, and insufficient investments in research and technology (non-cereals such as pulses, soyabeans, and cotton), high market barriers and weak post-harvest infrastructure (fruits and vegetables), and challenging non-economic policy (livestock).

6.54 It is easy to say what needs to be done. How this will happen given that agriculture is a state subject is an open political economy question.

Clearly, the Hirschmanian bottom-up forces of "voice" and "exit" along with benevolent-and-strategic top-down planning and reforms will all have to play a key part. The cooperative federalism "technology" of the GST Council that brings together the Center and States could be promisingly deployed to further agricultural reforms and durably raise farmers' incomes.

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07 CHAPTER

Gender and Son Meta-Preference: Is Development Itself an Antidote?

Nimirndha nan nadai naer konda paarvaiyum
Nilathil yaarkkum anjaatha nerigalum
Thimirndha gnana cherukkum iruppadhaal
Semmai maadhar thirambuvadhu illaiyaam

Her head held high, and looking everyone in the eye,
Unafraid of anyone because of innate integrity,
Possessing assuredness born of courage of conviction,
The Modern Woman never feels inferior to any

Subramania Bharati, "Pudumai Pen"

अबला जीवन तेरी हाय यही कहानी !
आंचल में है दूध और आंखों में पानी

Woman, this is your life story
Mothering your role, sadness your destiny

Maithlisharan Gupt

#MeToo

Over the last 10-15 years, India's performance improved on 14 out of 17 indicators of women's agency, attitudes, and outcomes. On seven of them, the improvement has been such that India's situation is comparable to that of a cohort of countries after accounting for levels of development. Encouragingly, gender outcomes exhibit a convergence pattern, improving with wealth to a greater extent in India than in similar countries so that even where it is lagging it can expect to catch up over time. However, on several other indicators, notably employment, use of reversible contraception, and son preference, India has some distance to traverse because development has not proved to be an antidote. Within India, there is significant heterogeneity, with the North-Eastern states (a model for the rest of the country) consistently out-performing others and not because they are richer; hinterland states are lagging behind but the surprise is that some southern states do less well than their development levels would suggest. The challenge of gender is long-standing, probably going back millennia, so all stakeholders are collectively responsible for its resolution. India must confront the societal preference, even meta-preference for a son, which appears inoculated to development. The skewed sex ratio in favor of males led to the identification of "missing" women. But there may be a meta-preference manifesting itself in fertility stopping rules contingent on the sex of the last child, which notionally creates "unwanted" girls, estimated at about 21 million. Consigning these odious categories to history soon should be society's objective. The government's Beti Bachao, Beti Padhao and Sukanya Samridhi Yojana schemes, and mandatory maternity leave rules are all steps in the right direction.

INTRODUCTION

7.1 Recognizing the long-run objective of elevating the role and status of women while also responding to prominent incidents of violence against women, the government in January 2015 launched "*Beti Bachao, Beti Padhao*". Translated roughly as "Save the Daughter, Educate the

Daughter", it targeted the worsening Child Sex Ratio (CSR) in India through a mass campaign aimed at creating awareness and changing social norms. As the advanced world grapples with the fallout from the endemic harassment of women, and as the evidence grows about the intrinsic and instrumental value in raising the role and status of women in society (Elbhorg-Woytek et al., 2013; Jayachandran, 2015), it is time to ask: how is India faring and how much progress has been made? Is India the land of the empowered woman imagined by Subramania Bharati or the helpless, oppressed woman described by Maithlisharan Gupt?

7.2 The intrinsic values of gender equality are uncontestable. But now there is growing evidence that there can also be significant gains in economic growth if women acquire greater personal agency, assume political power and attain public status, and participate equally in the labor force (Dollar and Gatti, 1999; Lagarde, 2016; Loko and Diouf, 2009). In developing countries, working women also invest more in the schooling of their children (Aguirre et al. 2012; Miller 2008). Recently at Davos, IMF chief Christian Lagarde, quoting IMF research, said that women's participation in the workforce to the level of men can boost the Indian economy by 27 percent.

7.3 Another reason to take stock is to correct a possibly pervasive methodological problem afflicting assessments relating to gender and other social issues. The problem is one of conflating "development time" and "chronological time." Gender indexes such as the Global Gender Gap Index of the World Economic Forum (WEF) or the Gender Inequality Index (GII) of the United Nations Development Program (UNDP) rank countries in chronological time.

7.4 But such simple cross-sectional comparisons are prone to a potential flaw. The role of women evolves with development. Scandinavia in the early 1900s was demonstrably less well-disposed to women than Scandinavia today, and possibly less well-disposed than countries today that have attained a level of development not dissimilar to Scandinavia in the early 1900s (Borchorst, 2008).

7.5 Thus, unless this determinant of gender outcomes is accounted for, cross-sectional comparisons—as in the two gender indices noted—could be misleading: a case of passing judgment in "chronological time" oblivious of "development time." Invoking "development time" is not to dismiss "chronological time" and not a ruse to succumb to the "soft bigotry of low expectations." Rather, policy-making should be informed by both perspectives. Urgency of action should spring from assessments in chronological time but that must be leavened by the understanding that comes from assessments in development time.

7.6 This distinction is crucial for another reason: if a country's performance is atypical in development time, the policy strategy will have to be far different from that if a country's performance is typical. In the former, bleaker case, development itself cannot be counted upon to improve the role and status of women. The burden on government, civil society, and other stakeholders will correspondingly be greater.

7.7 The first part of this chapter is an attempt at assessments after taking account of the role that development itself plays in changing gender outcomes. Specifically, two kinds of assessments are made:

- Level: How did India fare on a set of gender outcomes relative to a set of developing economies in the late 1990s/early 2000s and in the most recent period (2015-16), controlling for the level of development?
- Change: Is there a kind of convergence effect? That is, are gender indicators more responsive

to improvements in household wealth in India than in other countries?

7.8 Gender equality is an inherently multi-dimensional issue. But, embracing multi-dimensionality indiscriminately can impede understanding. Accordingly, assessments in this chapter are made on three specific dimensions of gender:

- **Agency** relate to women's ability to make decisions on reproduction, spending on themselves, spending on their households, and their own mobility and health.
- **Attitudes** relate to attitudes about violence against women/wives, and the ideal number of daughters preferred relative to the ideal number of sons.
- **Outcomes** relate to son preference (measured by sex ratio of last child), female employment, choice of contraception, education levels, age at marriage, age at first childbirth, and physical or sexual violence experienced by women.

7.9 The dimensions that are focused on and the assessments that are made are neither comprehensive nor necessarily representative, but they attempt to take into account the following: what the literature has focused on (Jayachandran, 2015); other important features specific to India that might have been overlooked; and more practical considerations of data availability, so that India can be compared with a large enough sample of countries.

7.10 The analysis in this chapter is based on the Demographic and Health Survey (DHS) datasets from 1980 to 2016. The survey has datasets at household level; both women and men are asked detailed questions on gender-related attitudes, agency and outcomes, among other issues. The India National Family Health Survey (NFHS) 2015-16, which feeds into the DHS survey, has been combined with international DHS datasets. Previous DHS/NFHS datasets for India are available for the following periods: 1992-93, 1998-99, and 2005-06.

7.11 Our main findings are as follows[1]:

- On 14 out of 17 indicators relating to agency, attitude, and outcomes, India's score has improved over time. On seven of them, the improvement is such that in the most recent period India's performance is better than or at par with that of other countries, accounting for the level of development.
- The progress is most notable in the agency women have in decision-making regarding, household purchases and visiting family and relatives. There has been a decline in the experience of physical and sexual violence. Education levels of women have improved dramatically but incommensurate with development.
- On 10 of 17 indicators, India has some distance to traverse to catch up with its cohort of countries. For example, women's employment has declined over chronological time, and to a much greater extent, in development time. Another such area is in the use of female contraception: nearly 47 percent of women do not use any contraception, and of those who do, less than a third use female-controlled reversible contraception. These outcomes can be disempowering, especially if they are the consequence of restrictions on reproductive agency. Whether women "choose" or acquiesce in their limited choices

[1] The "level" analysis (and the international comparison) is done after aggregating the variables of interest at country level, and at the level of states for the within-India comparison. To facilitate comparisons across time, states are defined by their 1995 borders. For the "change" analysis, household level data from NFHS 2015-16 has been used.

are important and deeper questions but beyond the scope of this chapter.

- Encouragingly, there is evidence of convergence. Analysis at household level indicates that on all but 2 measures, gender indicators improve as wealth increases. More importantly, from a development time perspective, nearly all gender dimensions respond to wealth to a greater extent in India than in other countries. This implies that even where India is lagging, it can expect to catch up with other countries as the wealth of Indian households increases.

- While there is considerable variation within the Indian states and across dimensions, the broad pattern is one of the North-Eastern states doing substantially better than the hinterland states even in development time; hinterland states are lagging, some associated with their level of development and some even beyond that; surprisingly, some southern states such as Andhra Pradesh and Tamil Nadu fare worse than expected given their level of development.

- Perhaps the area where Indian society—and this goes beyond governments to civil society, communities, and households—needs to reflect on the most is what might be called "son preference" where development is not proving to be an antidote. Son preference giving rise to sex selective abortion and differential survival has led to skewed sex ratios at birth and beyond, leading to estimates of 63 million "missing" women.

- But there is another phenomenon of *son meta-preference* which involves parents adopting fertility "stopping rules" – having children until the desired number of sons are born. This meta-preference leads naturally to the notional category of "unwanted" girls which is estimated at over 21 million. In some sense, once born, the lives of women are improving but society still appears to want fewer of them to be born.

- Collective self-reflection by Indian society on son preference and son meta-preference is necessary. Initiatives such as *Beti Bachao Beti Padhao* and *Sukanya Samridhi Yojana* and the mandatory maternity leave rules inaugurated by this government are important steps focused on addressing the underlying challenge.

INDIA AND OTHER COUNTRIES

Level: India's Performance

7.12 Table 1 summarizes the main findings. For each gender dimension (corresponding to questions in the DHS and NFHS 4), columns 1 and 2 report the average values for India for two time periods (2005-06 and 2015-16) and column 3 reports the change (in percentage points) for India between them. Column 4 assesses whether India is an outlier relative to other countries given its level of development (in 2015).

7.13 The positive news here is that on 12 out of 17 variables, average levels in India have improved over time. For example, 62.3 percent of women in India were involved in decisions about their own health in 2005-06, which increased to 74.5 percent in 2015-16. Similarly, the percentage of women who did not experience physical or emotional violence increased from 63 percent to 71 percent. The median age at first childbirth increased by 1.3 years over ten years.

7.14 On 7 out of these 12 cases, India performs better than, or at par with the cohort of other developing countries even after accounting for levels of development.

Table 1. Summary of Results

	Gender Dimension	Specific Issue# (Women's Responses)	(1) India 2005-06 (%)	(2) India 2015-16 (%)	(3) Change (2)-(1)	(4) Is India an Outlier for its level of wealth$ in 2015?
1	Agency	Involved in decisions about their own health	62.3	74.5	12.2	**8.2**
2	Agency	Involved in decisions about large household purchases	52.9	73.4	20.4	**9.6**
3	Agency	Involved in decisions about visits to family and relatives	60.5	74.6	14.1	**4.1**
4	Agency	Involved in decisions about their own earnings	82.1	82.1	-0.1	**-7.4**
5	Agency	Involved in decisions about contraception	93.3	91.6	-1.7	0.1
6	Attitude	Prefer more or equal number of daughters over sons	74.5	78.7	4.3	**-4.4**
7	Attitude	Wife beating is not acceptable	50.4	54.0	3.5	**-2.7**
8	Outcome	Using reversible contraception, if using any method of contraception	33.8	32.8	-1.0	**-51.6**
9	Outcome	Employed##	36.3	24.0	-12.3	**-26.0**
10	Outcome	Employed in non-manual sector##	18.9	28.2	9.3	**-19.8**
11	Outcome	Earning more than or equal to husband	21.2	42.8	21.6	**-7.4**
12	Outcome	Educated##	59.4	72.5	13.1	**-6.8**
13	Outcome	Not experiencing physical or emotional violence	62.6	70.5	7.8	0.3
14	Outcome	Not experiencing sexual violence	90.3	93.6	3.3	**1.7**
15	Outcome	Median age at first child birth*	19.3	20.6	1.3	**0.4**
16	Outcome	Median age at first marriage*	17.3	18.6	1.3	**-0.4**
17	Outcome	Sex ratio of last birth[2] (females per hundred births)	39.4	39.0	-0.4	**-9.5**

* Age is in years and is for year 1998-99.

All questions/responses are reported so that positive numbers denote greater female empowerment.

These dimensions are calculated for the set of all women between 15-49. All other dimensions are calculated for married women between the ages of 15 and 49. In column 4, the numbers represent the extent to which India is an outlier, positive or negative. They derive from the regression equation estimated at household level in Annex I. All numbers represent percentage points difference from the average estimated relationship, except for the numbers in rows 15 and 16 where they refer to number of years.

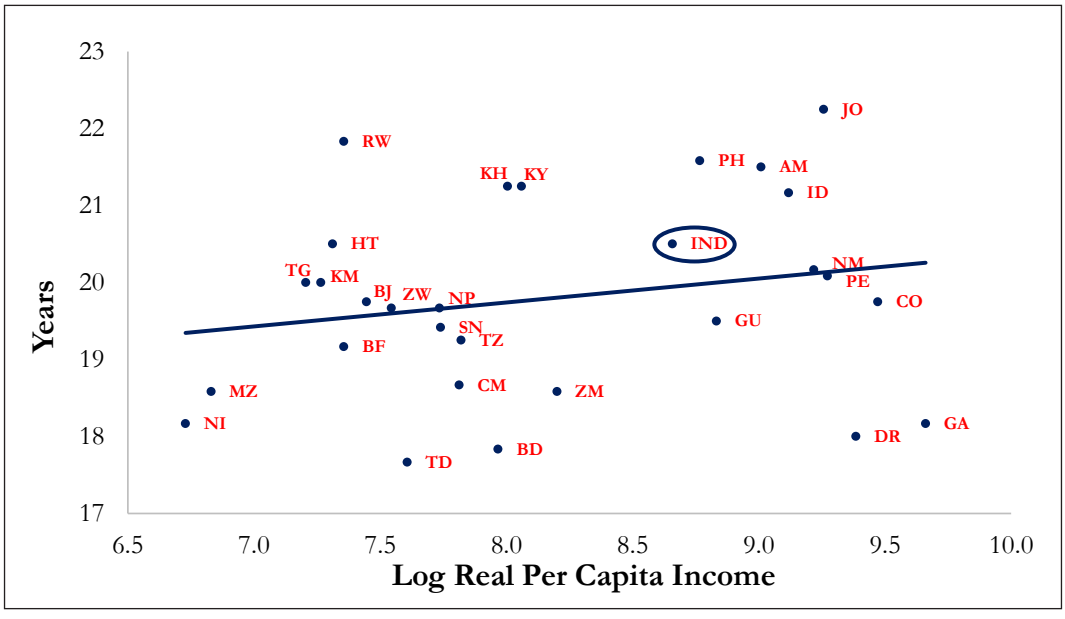
$ Numbers in bold are statistically significant.

Source: Survey calculations based on DHS and NFHS data.

7.15 Figure 1 provides visual illustration of India's (represented by "IND") progress on one such dimension – age of female at first childbirth, which improves by 1.3 years (6.9 percent) between 2005-06 and 2015-16. The median age of first childbirth for married women in these countries is plotted against log real per capita income. Given their level of wealth, Indian women perform better on age at first childbirth by 0.4 years.

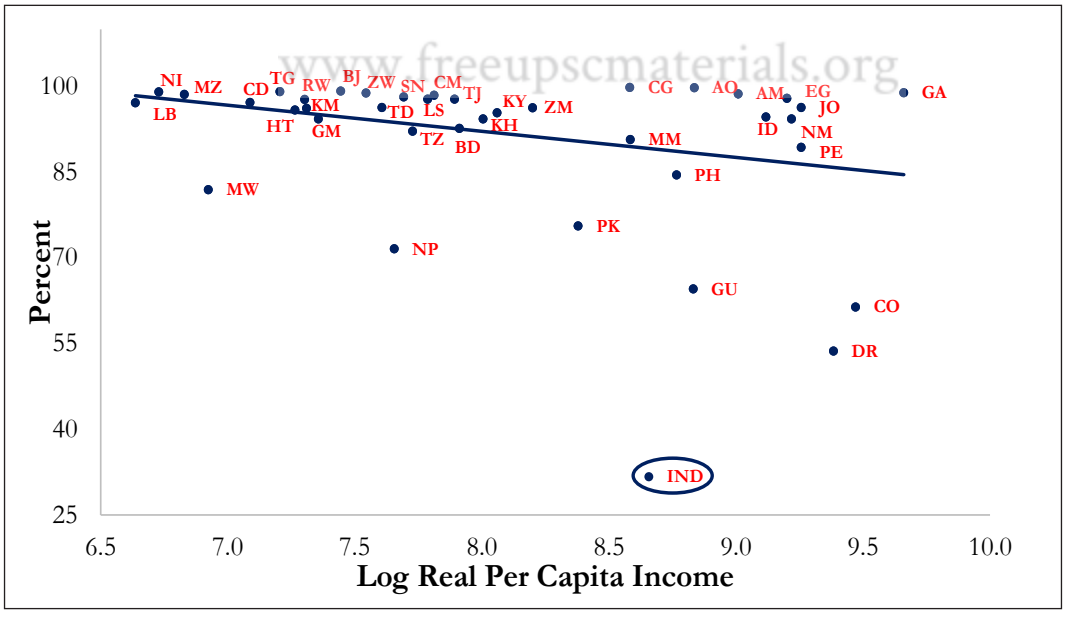
[2] To construct this indicator, besides births by sex, it is also necessary to know if the most recent birth is likely to be the last. To overcome this problem, the sample is restricted to only those women who either have been sterilized or have completed biological fertility cycle (older than 40 years).

Figure 1. Age of Female at First Childbirth in 2011-16



Source: CSO & Survey calculations based on DHS and NFHS data.

Figure 2. % of Women not Using Sterilization as a Contraception Method (2011-2016)



Source: CSO & Survey calculations based on DHS and NFHS data.

7.16 India has some distance to traverse on several dimensions (10 out of 17) to be on par with other countries in development time. One such dimension is the use of reversible contraception methods. For their level of wealth, the use of reversible contraception methods among Indian women is 51.6 percentage points lower than it should be.

7.17 Figure 2 explores this finding in greater detail. It plots the relationship between percentage of women not using sterilization as a contraception method (among women using any contraception method at all) and log real per capita income for the international sample. India is well below the

line of best fit. The number of married women in India who do not use any contraception method is high (46.5 percent). Among women using any contraception method at all, the percentage of Indian women using female-controlled reversible contraception is unusually low (32.8 percent).

7.18 These findings warrant attention: since not many women use methods of reversible contraception, they have little control over when they *start* having children, but only seem to have control over when they *stop* having children. This could affect other milestones early on in a woman's life; for example, women may not get the same access to employment that men do. Of course, these are important questions relating to how much true agency women have—whether they choose or acquiesce in their limited choices—but these are deeper questions beyond the scope of this chapter.

7.19 Another well documented finding relates to the percentage of women who work (row 9, Table 1), which has indeed declined over time (from 36 percent of women being employed in 2005-06 to 24 percent of women being employed in 2015-16). There is a long and contested literature on whether this decline is a cause for concern or will improve naturally with time and development. There is the more general phenomenon, documented by Goldin et. al. (1995), of a U-shaped behavior of female labor force participation with respect to development. India is on the downward part of the "U" but even more so than comparable countries.

7.20 On the supply side, increased incomes of men allows Indian women to withdraw from the labor force, thereby avoiding the stigma of working; higher education levels of women also allow them to pursue leisure and other non-work activities all of which reduce female labor force participation. (Bhalla and Kaur, 2011; Kapsos, 2014; Klasen, 2015). On the demand side, the structural transformation of Indian agriculture due to farm mechanization results in a lower demand for female agricultural laborers (Chatterjee et al., 2015; Mehrotra et al., 2017). Evidence also points to insufficient availability of the types of jobs that women say they would like to do—regular, part-time jobs which provide steady income and allow women to reconcile household duties with work—and types of sectors that draw in female workers. (Kannan and Raveendran, 2012; Chand and Srivastava, 2014) This, interacted with safety concerns and social norms about household work and caring for children and elders ,militates against women's mobility and participation in paid work (Pande et al., 2016; Prillaman et al., 2017).

7.21 Finally, the sex ratio of last birth is biased against females and is lower by 9.5 percentage points in 2015-16 in comparison to other countries. And this has remained stagnant in the last decade. The sections on son preference and son meta–preference discuss the implications of this finding in greater detail.

Is there a convergence effect?

7.22 The next assessment undertaken is at the household level to see if gender related indicators improve with wealth both in India as well as other countries.[3] Table 2 summarizes the results (Annex I provides the details of the regression specification used for this analysis).

7.23 Column 1 shows the impact on the relevant gender indicator of one standard deviation increase in wealth in the typical country in the sample. For example, row 1 indicates that if wealth increases by one standard deviation in the average country, the number of women involved in decision making on their health increases by 5.5

[3] The wealth of a household comes from the wealth factor score provided by DHS/NFHS 4. This score is based on the number and type of assets owned. This wealth factor score is normalized for the size of the household by dividing it by the household size, giving a measure of average wealth at the individual level.

[4] One caveat is that the unit of wealth measured here is a relative not an absolute one so it may not represent comparable increases in wealth across countries.

Table 2. Responsiveness of Gender Dimensions to Wealth— India and other Countries*

	Gender Dimension	Specific Issue (Women's Response)	(1) Effect of wealth[$] for other countries (%)	(2) Additional effect of wealth[$] in India (%)	(3) = (1) +(2) Total effect of wealth[$] in India (%)
1	Agency	Involved in decisions about their own health	**5.5**	**4.7**	**10.2**
2	Agency	Involved in decisions about large household purchases	**6.4**	**4.4**	**10.7**
3	Agency	Involved in decisions about visits to family and relatives	**5.5**	**8.2**	**13.6**
4	Agency	Involved in decisions about their own earnings	**3**	**7.2**	**10.2**
5	Agency	Involved in decisions about contraception	**0.5**	**6.6**	**7.1**
6	Attitude	Prefer more or equal number of daughters over sons	**1.9**	**25.3**	**27.2**
7	Attitude	Wife beating is not acceptable	**11.5**	**12.9**	**24.4**
8	Outcome	Using reversible contraception, if using any method of contraception	**-1.5**	**19.2**	**17.7**
9	Outcome	Employed[#]	**3.2**	**-19.9**	**-16.7**
10	Outcome	Employed in non-manual sector[#]	**20.6**	**52.4**	**72.9**
11	Outcome	Earning more than or equal to husband	**3**	**7.2**	**10.2**
12	Outcome	Educated[#]	**10.6**	**59.9**	**70.6**
13	Outcome	Not experiencing physical or emotional violence	**2.1**	**31.3**	**33.5**
14	Outcome	Not experiencing sexual violence	**1.2**	**8.2**	**9.4**
15	Outcome	Median age at first child birth**	**1.2**	**1.7**	**2.9**
16	Outcome	Median age at first marriage**	**1.4**	**2.6**	**4.0**
17	Outcome	Sex ratio of last birth (females per hundred births)	0.5	**-2.2**	**-1.7**

*Numbers indicate the improvement in score with a 1 standard deviation increase in household wealth.

**Median Age in years for 1998-99.

#These dimensions are calculated for the set of all women between 15-49. All other dimensions are calculated for married women between the ages of 15 and 49. They derive from the equation estimated at household level in Annex I. All numbers represent percentage points difference from the average estimated relationship, except for the numbers in rows 15 and 16 where they refer to number of years.

$ Numbers in bold are statistically significant.

Source: Survey calculations based on DHS and NFHS data.

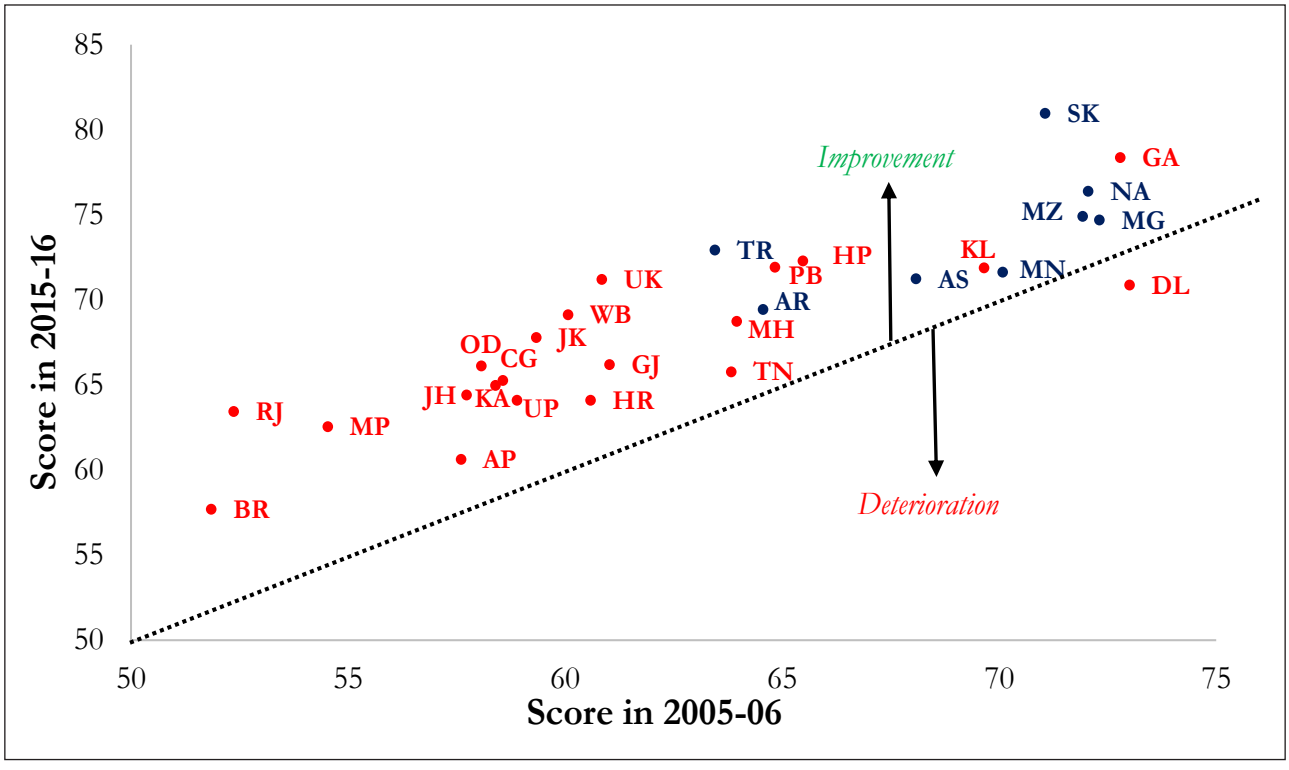
percentage points. Column 2 shows that in India, the number of women having agency on health matters increases by a further 4.7 percentage points for a one standard deviation increase in wealth. Column 3 shows the overall effect in India, in this case a 10.2 percentage point increase (4.7+5.5) for one standard deviation increase in wealth.

7.24 The key finding from Table 2 is that in 15 out of 17 cases, gender indicators are more responsive to wealth in India than they are in the typical country (15 out of 17 coefficients in column 2 are positive).[4] This suggests that even if India is lagging in development time, it can expect to catch up with other countries as household wealth increases.[5,6]

[5] Strictly speaking, this convergence effect would hold only if India's wealth coefficient is greater than that of the richer countries in the sample. That does turn out to be true and statistically significant (results not reported).

[6] In some cases, India might artificially seem to outperform other countries (in terms of responsiveness) because the level of certain variables may be closer to the maximum limit in other countries to begin with, therefore leaving them little or no scope for improvement with wealth.

Figure 3. Average Gender Score for Indian States



Source: Survey calculations based on NFHS 4 data.

7.25 It is notable that the only two cases where such a convergence effect is not visible and where India appears to be falling behind even in development time (where the effect of wealth in India is negative in column 3) is on women's employment and sex of last child. The low numbers of female last children are explored in greater detail in sections on son preference and son meta–preference.

PERFORMANCE OF THE INDIAN STATES

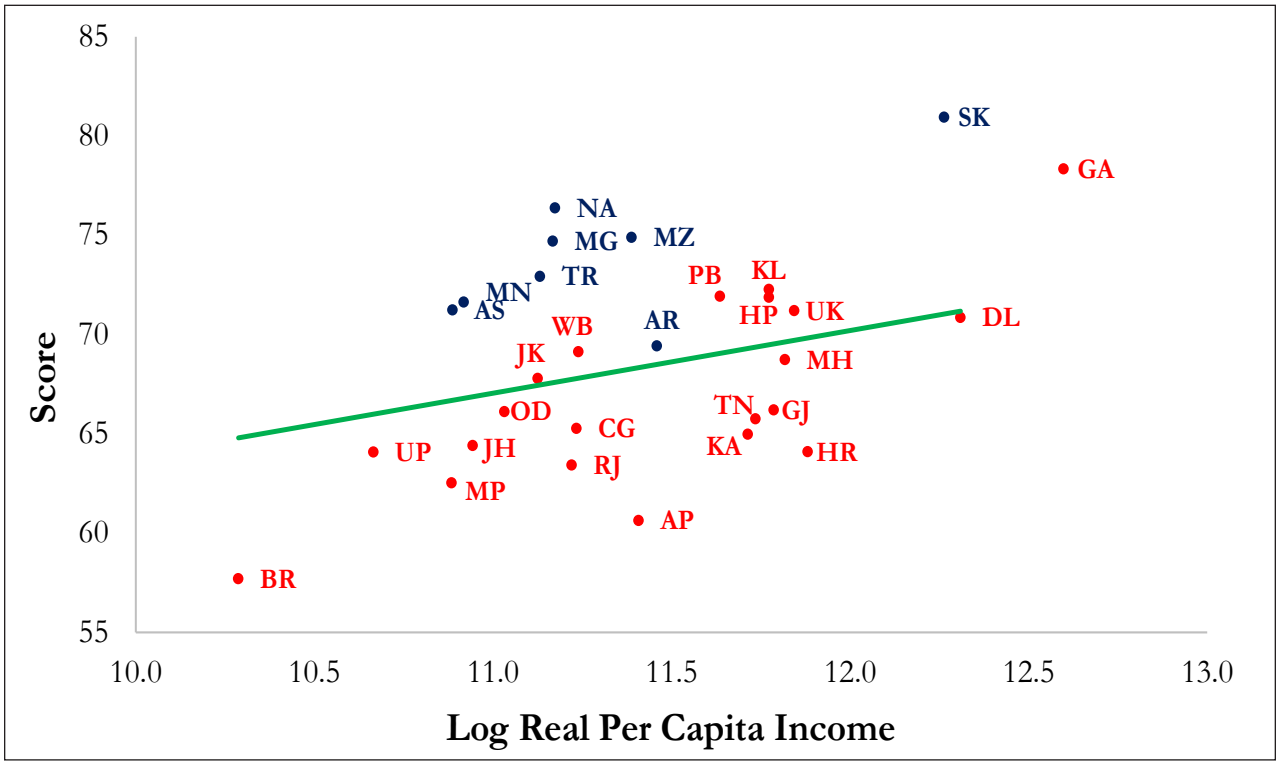
7.26 How do the Indian states perform relative to each other and relative to their level of development? To shed some light on this, the scores of the Indian states across all the dimensions are averaged.[7] Figure 3 shows the average score of each state in the two time periods. The variables are calibrated such that the maximum score is 100 percent. The scores of the states in 2005-06 are on the x-axis and the score in 2015-16 are on the y-axis, with the 45-degree line helping in the understanding of movements over time. North-Eastern states have been colored blue. All the other states are colored red.

7.27 A few patterns emerge. All states (with the exception of Delhi) are above the 45-degree line, underscoring the earlier results that there is improvement over time. Indeed, there is also a "convergence" effect in that the poorer performers in the earlier period improve their score more over time (the dots at the lower end have shifted up to a greater extent relative to the 45-degree line compared with dots at the upper corner).

7.28 Second, most North-Eastern states (with the exception of Tripura and Arunachal Pradesh)

[7] To arrive at a score for each state, the state-wise percentage for each one of these variables in attitude, agency, and outcome is first calculated. For the age-related variables (age at first marriage and age at first birth), the state-level median ages are calculated and normalized with respect to the average age of marriage and first birth in Sweden (33 years and 29 years, respectively). For the percentage of females in the labor force, the current benchmark is placed at 72 per cent of the female population, which is the Swedish national average of female labor force participation, and Indian responses are normalized.

Figure 4. Gender Score vs. Per Capita Income for Indian States in 2015



Source: Survey calculations based on NFHS 4 and CSO data.

and Goa occupy the North-East quadrant, indicating that they are the best performers at all points of time. Kerala is the next best performer. The lagging performers are Bihar, Rajasthan, Madhya Pradesh, Uttar Pradesh, Jharkhand and, surprisingly, Andhra Pradesh. Delhi's performance actually worsens in a decade, and it falls from having the highest score in 2005-06 (going from 73 in 2005-06 to 70.9 in 2015-16).

7.29 Finally, since there is a theoretically perfect score of 100, the distance of the Indian states from their absolute frontier can be assessed. The worst Indian score is 57.6 (Bihar) and the best is 81 (Sikkim) with most of India scoring between 55 and 65 (about 40 per cent away from the frontier). Indian states have some distance to traverse to reach the theoretical frontier.

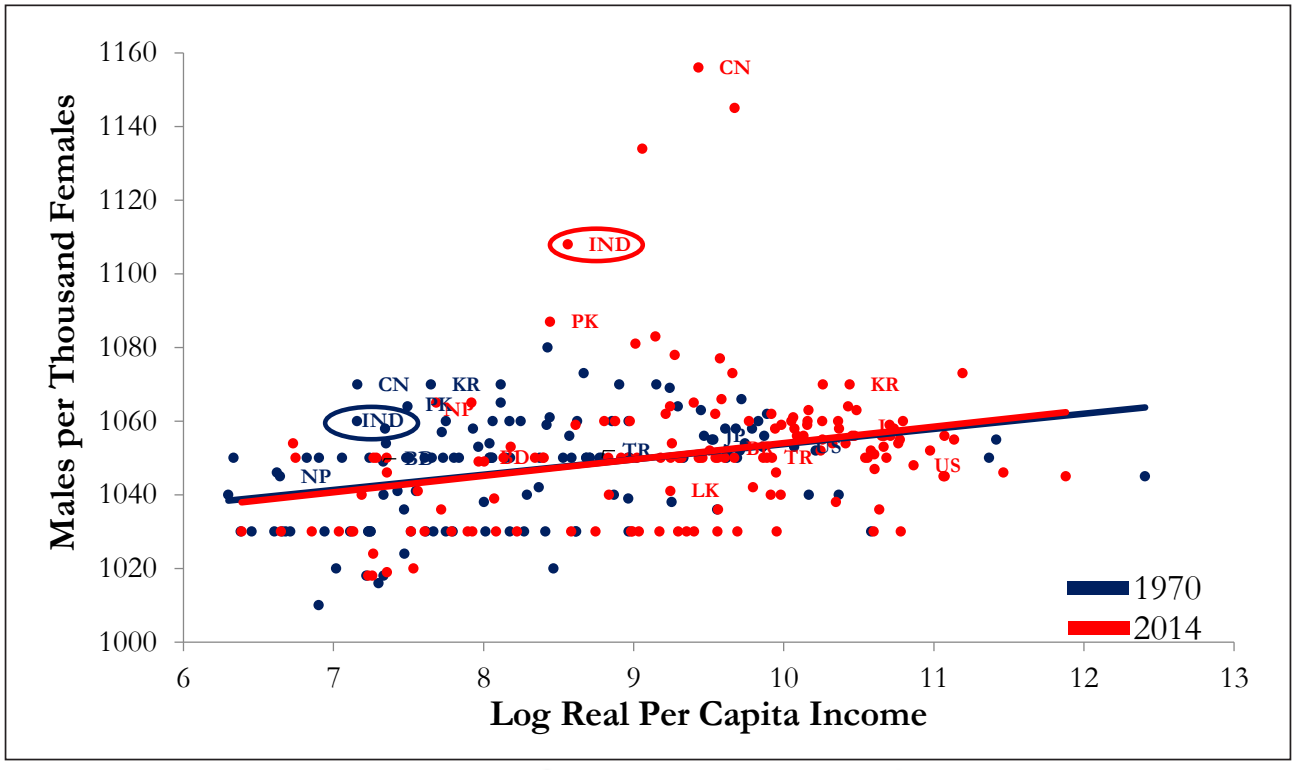
7.30 Figure 4 plots the gender score for Indian states in 2015 against log per capita income, and hence conveys how states are performing in "development time." Here, the North-Eastern states have much better gender scores given their levels of income (they are well above their line of best fit). On the other hand, accounting for their levels of income, Andhra Pradesh, Haryana, Bihar and Tamil Nadu perform less well.

SON PREFERENCE: SKEWED SEX RATIO AT BIRTH (SRB)

7.31 Issues relating to son preference are a matter for Indian society as a whole to reflect upon. Because it is a long-standing historical challenge, all stakeholders are collectively responsible for its existence and for its resolution. Figure 5 plots the Sex Ratio at Birth (SRB) for countries in 1970 and 2014 against their level of real per capita income. India and China are well above the regression line, suggesting that there are many more males to females after accounting for development levels.

7.32 The biologically determined natural sex ratio at birth is 1.05 males for every female.[8] Any

Figure 5. Sex Ratio at Birth and Real Per Capita Income (1970 and 2014): International Comparison



Source: World Development Indicators and Penn World Tables.

significant deviation from this is on account of human intervention – specifically, sex-selective abortion. In the case of China, the one-child policy interacted with the underlying son-preference to worsen the sex ratio from 1070 in 1970 to 1156 in 2014. India's sex ratio during this period also increased substantially even without the one-child policy from 1060 to 1108 whereas if development acted as an antidote, it should have led to improvements in the sex ratio.

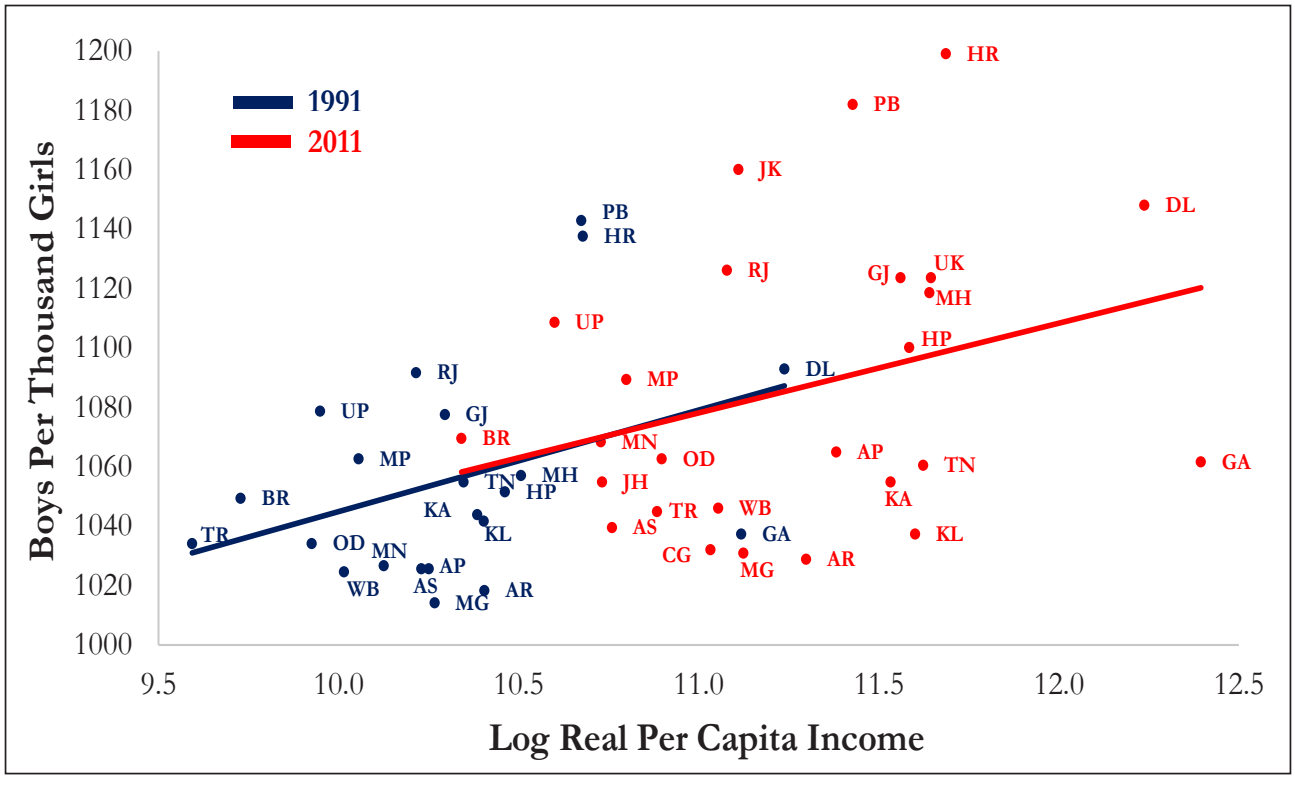
7.33 Figure 6 plots the sex ratio for the different states in India in 1991 and in 2011. It is striking that there is a general upward drift in sex ratio and the regression line is also upward sloping, indicating a negative correlation between income and sex ratio (a worsening in development time). Most striking is the performance of Punjab and Haryana where the sex ratio (0-6 years) is approaching 1200 males per 1000 females, even though they are amongst the richest states.

7.34 Several decades ago, Sen (1990), noting the skewed ratio of females to males, estimated that nearly 100 million women were missing in the world (almost 40 million in India alone). A large part of this is driven by a combination of sex-selective abortion as well as neglect of the girl child after birth.

7.35 Using the methodology of Sen (1990) and Anderson & Ray (2010, 2012), the total stock as well as the flow of "missing women" in India are updated. The stock of missing women as of 2014 was nearly 63 million and more than 2 million women go missing across age groups every year (either due to sex selective abortion, disease, neglect, or inadequate nutrition).

[8] Evolutionarily, boys have a slightly lower probability of survival in infancy, and are therefore born at a slightly higher rate. Together, these ensure that the sex ratio in adulthood is 1:1 in accordance with Fisher's principle.

Figure 6. Sex Ratio (0-6 years) and Real Per Capita Income For Indian States



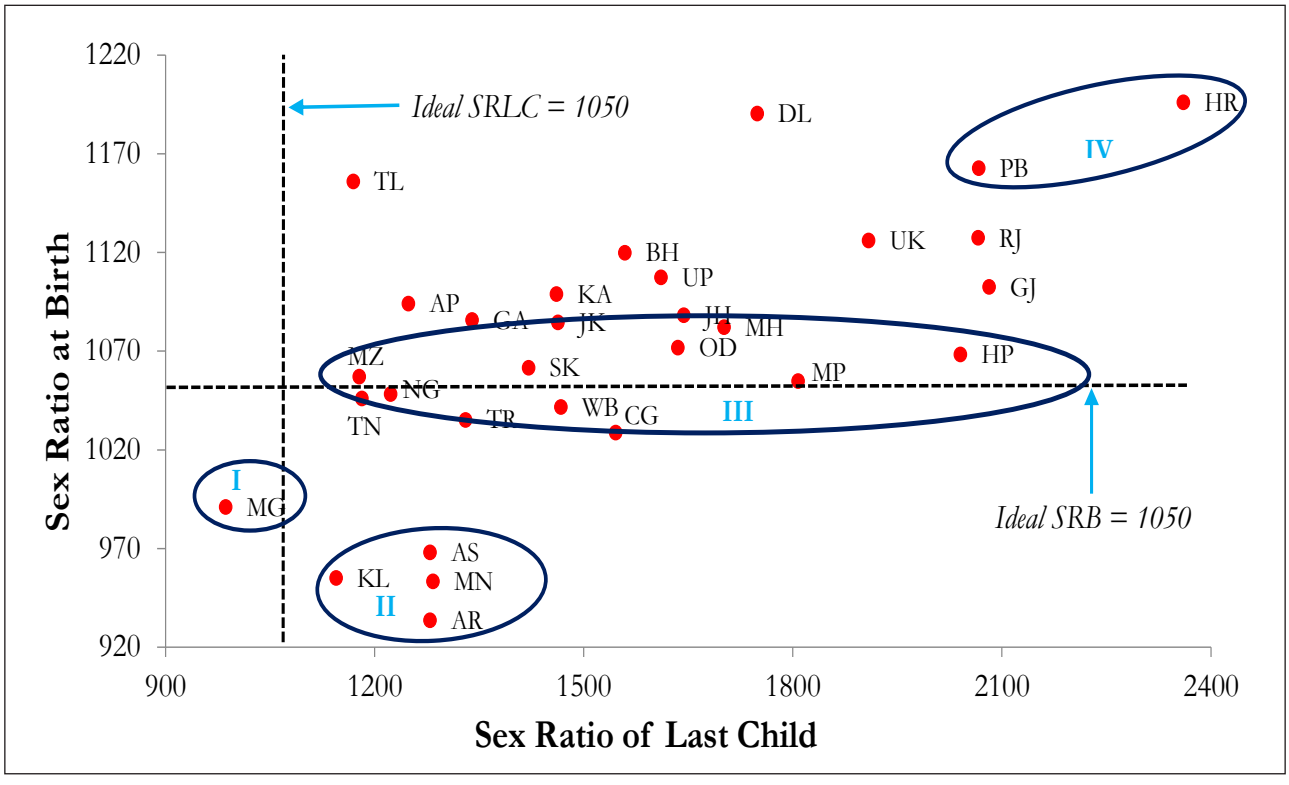
Source: Census of India & CSO.

SON "META" PREFERENCE: SEX RATIO OF LAST CHILD (SRLC) AND "UNWANTED" GIRLS

7.36 While active sex selection via fetal abortions is widely prevalent, son preference can also manifest itself in a subtler form. Parents may choose to keep having children until they get the desired number of sons. This is called son "meta" preference. A son "meta" preference – even though it does not lead to sex-selective abortion – may nevertheless be detrimental to female children because it may lead to fewer resources devoted to them (Jayachandran & Pande, 2017). The important thing to note is that this form of sex selection alone will not skew the sex ratio – either at birth or overall. Therefore, a different measure is required to detect such a "meta" preference for a son. One indicator that potentially gets at this is the sex ratio of the last child (SRLC). A preference for sons will manifest itself in the SRLC being heavily skewed in favor of boys. On the other hand, an SRLC of close to 1.05:1 would imply that parents' decisions to continue having children is uncorrelated with previous birth being a son or a daughter. Families continue to have children until they get the desired number of sons. This kind of fertility stopping rule will lead to skewed sex ratios but in different directions: skewed in favor of males if it is the last child, but in favor of females if it is not (see the two panels on India below). Where there is no such fertility stopping rule, the sex ratio will be 1.05 regardless of whether the child is the last one or not.

7.37 India after outlawing sex selection (via the implementation of Pre-Natal Diagnostic Techniques (PNDT) Act, 1994) saw a stabilization of its sex ratio at birth (see Annex II), albeit at an elevated level. However, it is not clear whether it resulted from changes in societal preferences or due to increased state regulation of sex-detection technology. SRLC helps us better understand and decompose the underlying factors (Yoo et al., 2016).

Figure 7. Sex Preference – "Malign" and "Meta" (Male Per Thousand Females)



Source: Survey calculations based on NFHS 4.

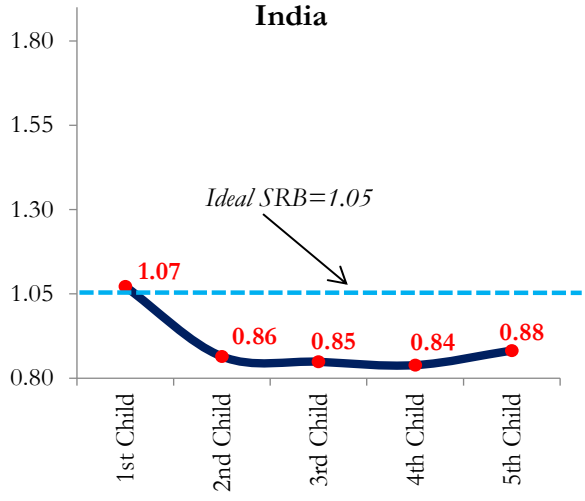
7.38 Figure 7 plots the SRLC against the SRB for Indian states. The dashed vertical and horizontal lines represent the "ideal" benchmark with no son preference. Meghalaya stands out as an ideal state because both sex ratio at birth and sex ratio of last child are close to the benchmark. States in circle II and circle III, such as Kerala, do not seem to practice sex selective abortions (since their sex ratios at birth are close to the biological benchmark) but indicate some son "meta" preference (skewed SRLC). Punjab and Haryana, on the other hand, exhibit extremely high son preference and meta preference – the overall sex ratios are significantly above the biological benchmark, and the sex ratio of the last child is heavily male skewed, implying parents are unlikely to stop after having a daughter.

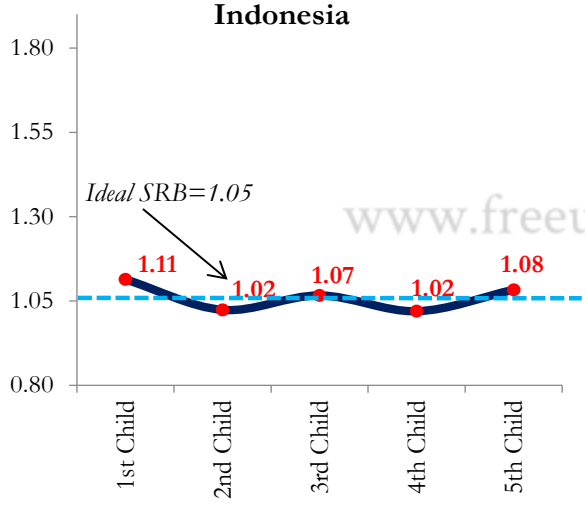
7.39 This son "meta" preference is depicted in Figures 8a and 8b. All the left-hand panels show the sex ratio for each birth order among families that had strictly more than one child (i.e. which continued having children after the first birth). So, in India (top left panel), the sex ratio of the first child for households that have strictly more than 1 child is 1.07. Similarly, 0.86 is the sex ratio of the second child among families that had strictly more than 2 children.

7.40 In contrast, the top panel of Figure 8b shows the sex ratio of the last child by birth order. For India, the sex ratio of the last child for first-borns is 1.82, heavily skewed in favor of boys compared with the ideal sex ratio of 1.05. This ratio drops to 1.55 for the second child for families that have exactly two children and so on. The striking contrast between the two panels conveys a sense of son meta preference. This contrast is even more stark when seen against the performance of Indonesia (middle panels) where the SRLC is close to the ideal, regardless of the birth order and whether the child is the last or not.

7.41 What do these figures imply? Families where a son is born are more likely to stop having children than families where a girl is born. This is suggestive of parents employing "stopping rules"

Figure 8a. Sex Ratio by Birth when Child is not the Last





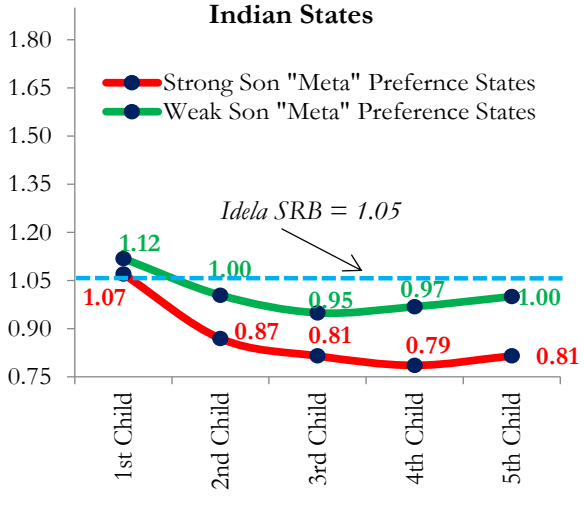
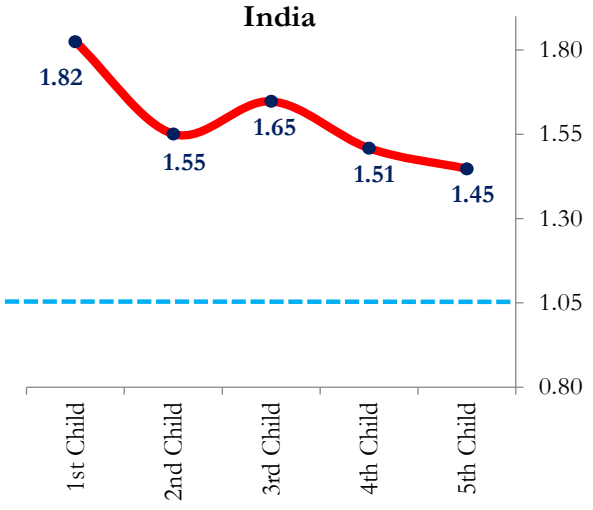
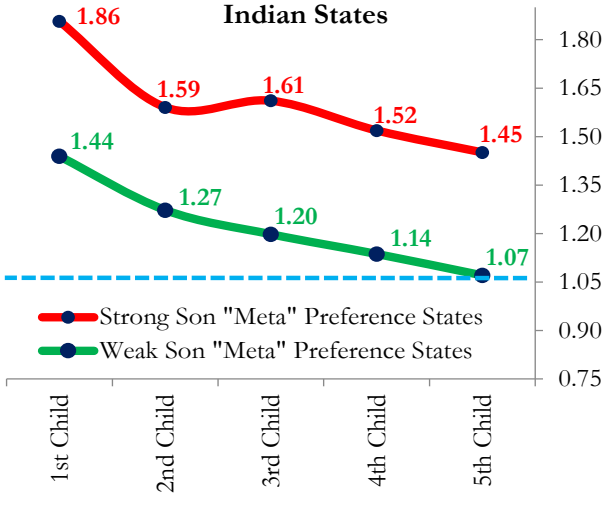


Figure 8b. Sex Ratio by Birth when Child is the Last





Source: Survey calculations based on DHS and NFHS 4.

– having children till a son is born and stopping thereafter. The only exception to this pattern is with regards to the first child. Even parents who have a first-born son are likely to continue having children, which reflects a pure family size preference – Indian parents, on average, want to have at least two children.

7.42 Jayachandran (2015) lists a number of reasons for such a son preference, including patrilocality (women having to move to husbands' houses after marriage), patrilineality (property passing on to sons rather than daughters), dowry (which leads to extra costs of having girls), old-age support from sons and rituals performed by sons.

7.43 The bottom panels are for the Indian states, distinguishing between states that exhibit strong son "meta" preference, such as Punjab and Haryana (red line) and the states that exhibit weak son "meta" preference, such as the North-Eastern states (green line). There is again a striking contrast in meta preference for sons within India between states.

7.44 Such meta preference gives rise to "unwanted" girls–girls whose parents wanted a boy, but instead had a girl. This chapter presents the first estimate of such notionally "unwanted" girls. This is computed as the gap between the benchmark sex ratio (dotted line) and the actual sex ratio among families that do not stop fertility (in the left panel of Figure 8a; see Annex III for details). This method yields the number of unwanted girls as 21 million.[9]

CONCLUSION

7.45. Analysis of multiple rounds of the Demographic Health Survey (DHS) and National Family Health Survey (NFHS) data indicates that over the last 10-15 years, India's performance has improved on 14 out of 17 indicators of women's agency, attitudes, and outcomes. On seven of them, the improvement has been such that India's situation is comparable to, or better than, that in a cohort of countries after accounting for levels of development.

7.46. On several dimensions, employment and use of reversible contraception in particular, India has some distance to traverse to catch up with other countries because development on its own has not proved to be an antidote.

7.47. Encouragingly, gender outcomes exhibit a convergence pattern, improving with wealth to a greater extent in India than in similar countries so that even where it is lagging it can expect to catch up over time.

7.48. Within India, there is significant heterogeneity, with the North-Eastern states (a model for the rest of the country) consistently out-performing other states and not because they are richer; hinterland states are lagging behind but the surprise is that some southern states do less well than their development levels would suggest.

7.49. Because the challenge is historical and long-standing, no one stakeholder is responsible for creating it or solving it. On gender, society as a whole—civil society, communities, households—and not just any government must reflect on a societal preference, even meta-preference for a son, which appears inoculated to development. The adverse sex ratio of females to males led to 63 million "missing" women. But the meta-preference manifests itself in fertility-stopping rules contingent on the sex of the last child, which notionally creates "unwanted" girls, estimated at about 21 million. Tellingly, for example, skewed sex ratios characterize families of Indian origin, even in Canada (Srinivasan, 2017).

7.50. Given these observations, the state and all stakeholders have an important role to play in increasing opportunities available for women in education and employment. Understanding the importance of its role, the government has launched the *Beti Bachao Beti Padhao* and *Sukanya Samridhi Yojana* schemes. It has also made 26 weeks maternity leave mandatory for women employed

[9] This is the stock of unwanted girls for the 0-25 age group in the population currently.

in the public and private sectors. Further, every establishment that has more than 50 employees is now required to offer creche facilities. These steps will offer support to women in the workforce. In this somewhat unequal contest between the irresistible forces of development and the immovable objects that are cultural norms, the former will need all the support it can get – and then some.

7.51. Just as India has committed to moving up the ranks in the ease of doing business indicators, it should perhaps do so on gender outcomes as well. Here, the aim should be broader. Many of the gender outcomes are manifestations of a deeper societal preference, even meta-preference for boys, leading to many "missing" women and "unwanted" girls. So, Indian society as a whole should perhaps resolve—the miles to go before society can sleep in good conscience—to consign these odious categories to history soon.

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Transforming Science and Technology in India

08
CHAPTER

We need a spirit of victory, a spirit that will carry us to our rightful place under the sun, a spirit which can recognize that we, as inheritors of a proud civilization, are entitled to our rightful place on this planet. If that indomitable spirit were to arise, nothing can hold us from achieving our rightful destiny

C. V. Raman

Innovations in science and technology are integral to the long-term growth and dynamism of any nation. The pursuit of science also creates a spirit of enquiry and discourse which are critical to modern, open, democratic societies. Historically, India can point to many contributions to global scientific knowledge and technological achievement. However, India under-spends on research and development (R&D), even relative to its level of development. A doubling of R&D spending is necessary and much of the increase should come from the private sector and universities. To recapture the spirit of innovation that can propel it to a global science and technology leader—from net consumer to net producer of knowledge—India should invest in educating its youth in science and mathematics, reform the way R&D is conducted, engage the private sector and the Indian diaspora, and take a more mission-driven approach in areas such as dark matter, genomics, energy storage, agriculture, and mathematics and cyber physical systems. Vigorous efforts to improve the "ease of doing business" need to be matched by similar ones to boost the "ease of doing science."

WHY SCIENCE

8.1 Science, technology, and innovation have instrumental and intrinsic value for society. They are key drivers of economic performance and social well-being. But they are also important for deeper reasons: a scientific temper, with its spirit of enquiry, the primacy accorded to facts and evidence, the ability to challenge the status quo, the adherence to norms of discourse and the elevation of doubt and openness. The open spirit of inquiry that is fundamental to science can provide a bulwark against the darker forces of dogma, religious obscurantism, and nativism that are threateningly resurfacing around the world.

8.2 As India emerges as one of the world's largest economies, it needs to gradually move from being a net consumer of knowledge to becoming a net producer. Its historical contributions to science have been many, ranging from one of the most important innovations in the history of

mathematics – the first use of zero – as revealed in the Bakhshali manuscript (carbon dated to AD 200–400), to important contributions made (amongst others) by Aryabhata, Brahmagupta, Bhaskara, Madhava of Sangamagrama, and to the stellar contributions made by names such as CV Raman, S. N. Bose, Srinivasa Ramanujan in the last century.

8.3 And, independent India has chalked up many accomplishments: from the nuclear energy program, the hybrid seeds program that underpinned the Green Revolution to the space program, including the *Mangalyaan* mission which highlighted India's niche of doing cost-effective, high-technology research. Most recently, India's important participation (involving three major Indian research institutions) in the Laser Interferometer Gravitational-wave Observatory (LIGO) experiment successfully detected the existence of gravitational waves. And India's vaccines and generic-drugs have saved millions of lives the world over.

8.4 However, a country cannot rest on its past laurels. Given the dizzying pace and expansion of scientific research and knowledge on the one hand, and a generally higher importance given to careers in engineering, medicine, management and government jobs amongst India's youth on the other, India needs to rekindle the excitement and purpose that would attract more young people to the scientific enterprise. Doing so would lay the knowledge foundations to address some of India's most pressing development challenges in addition to maintaining a decent, open society. Investing in science is also fundamental to India's security: the human security of its populations; the resilience needed to address the multiple uncertainties stemming from climate change; and the national security challenges stemming from new emerging threats, ranging from cyberwarfare to autonomous military systems such as drones.

INPUTS AND OUTPUTS: SOME EVIDENCE

Research and Development Expenditures

8.5 Investments in Indian science, measured in terms of Gross Expenditure on R&D (GERD), have shown a consistently increasing trend over the years. GERD has tripled in the last decade in nominal terms – from Rs. 24,117 crores in 2004-05 to Rs. 85,326 crores in 2014-15 and an estimated Rs.1,04,864 crores in 2016-17 – and double in real terms (Table 1). However, as a fraction of GDP, public expenditures on research have been stagnant – between 0.6-0.7 percent of GDP – over the past two decades. Public expenditure is dominant, although its share has come down from three-fourths of all expenditures to about three-fifths.

8.6 About three-fifths of the public investment is spread over the key government science funding agencies like Atomic Energy, Space, Earth Sciences, Science and Technology and Biotechnology (Table 2). Given the country's

Table 1. R&D Expenditure (Rs. Crores and per cent of Nominal GDP in parentheses)

Year	Public Investment in R&D	Private Investment in R&D	Total
2004-05	18078 (0.5%)	6039 (0.2%)	24117 (0.7%)
2008-09	32988 (0.5%)	14365 (0.2%)	47353 (0.7%)
2012-13	46886 (0.4%)	27097 (0.2%)	73983 (0.6%)
2016-17*	60869 (0.4%)	43995 (0.3%)	104864 (0.7%)

Source: Dept. of Science & Technology (DST); World Bank.

Note: Public Investments in R&D = Central Government Ministries/Department + Public Sector/joint sector industries+ State Government + Higher Education.

Table 2. Expenditure of Principal Science Government Agencies (Rs. Crores)

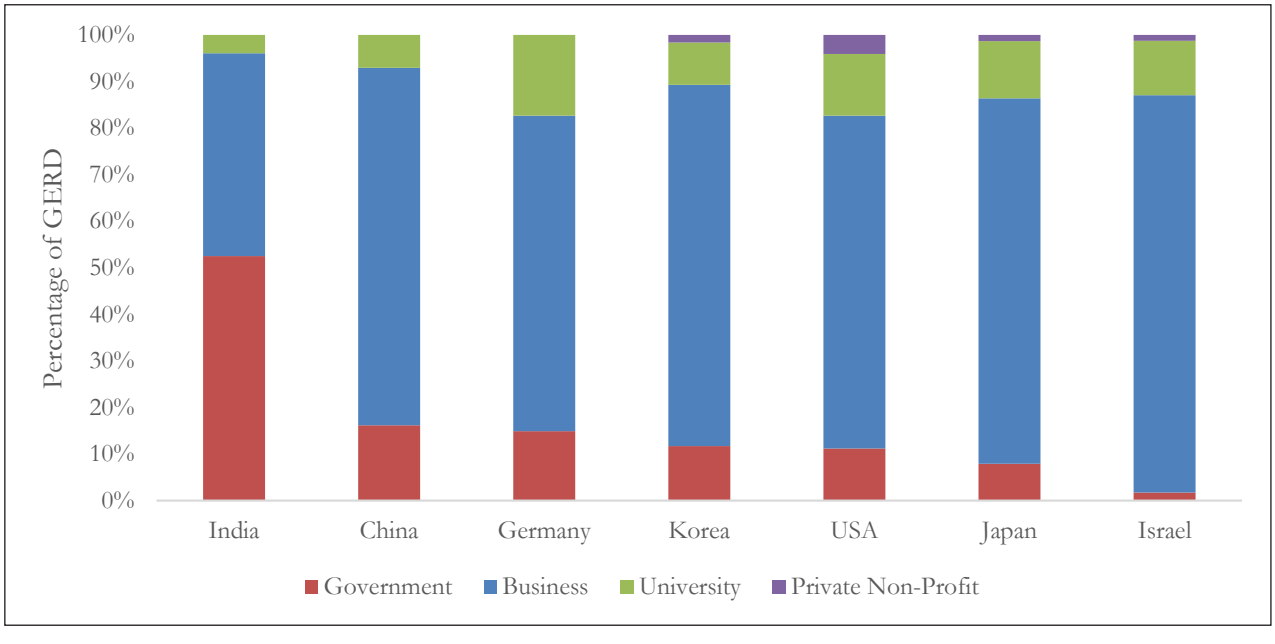
Agency	2010-11	2012-13	2014-15
1. Council of Scientific & Industrial Research (CSIR)	2929	2910	3335
2. Defense Research & Development Org. (DRDO)	10149	9895	13258
3.Department of Atomic Energy (DAE)	2855	3191	4075
4. Department of Biotechnology (DBT)	921	1031	1021
5. Department of Science & Technology (DST)	2133	2378	2701
6. Department of Space (DOS)	4482	4856	5818
7. Indian Council of Agricultural Research (ICAR)	3182	3569	3983
8. Indian Council of Medical Research (ICMR)	679	808	843
Total	**27330**	**28636**	**35034**

Source: DST.

severe health challenges, the low – and virtually stagnant in real terms – budget of the ICMR is striking.

8.7 India's spending on R&D (about 0.6 percent of GDP) is well below that in major nations such as the US (2.8), China (2.1), Israel (4.3) and Korea (4.2). It is also unique in how dominant government is in carrying out R&D. In most countries, the private sector carries out the bulk of research and development even if government must play an import funding role. However, in India, the government is not just the primary source of R&D funding but also its the primary user of these funds (Figure 1). Even more, government expenditure on R&D is undertaken almost entirely by the central government. There is a need for greater State Government spending, especially application oriented R&D aimed at problems specific to their economies and populations.

Figure 1. GERD on R&D by Performer Share in 2015



Source: United Nations Educational, Scientific, and Cultural Organization (UNESCO).

8.8 Private investments in research have severely lagged public investments in India. According to one analysis (Forbes, 2017) there are 26 Indian companies in the list of the top 2,500 global R&D spenders compared to 301 Chinese companies. 19 (of these 26) firms are in just three sectors: pharmaceuticals, automobiles and software. India has no firms in five of the top ten R&D sectors as opposed to China that has a presence in each of them.

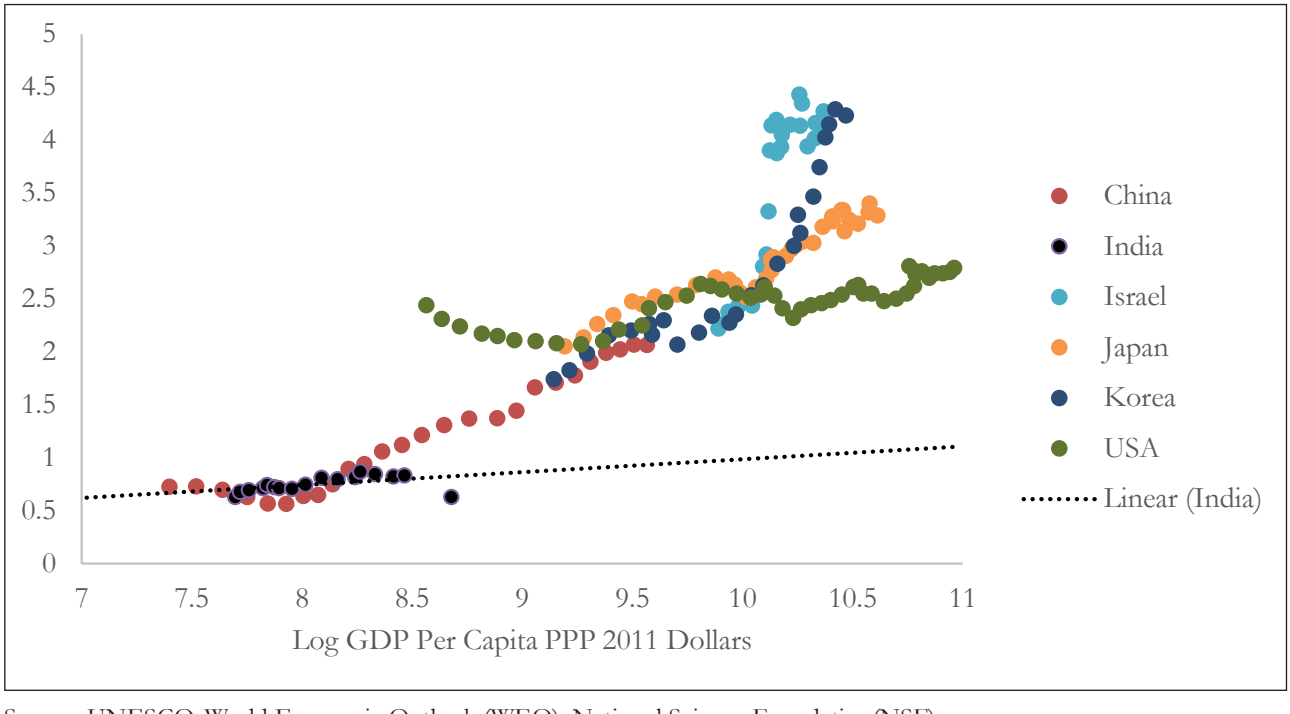
8.9 India is also distinctive in another dimension: its universities play a relatively small role in the research activities of the country. Universities in many countries play a critical role in both creating the talent pool for research as well generating high quality research output. However, publicly funded research in India concentrates in specialized research institutes under different government departments. This leaves universities to largely play a teaching role – a decision that goes back to the 1950s. It is now widely acknowledged that whatever the merits of the decision at the time, this disconnection has severely impaired both teaching as well as the research enterprise in the country.

8.10 One way of assessing if India spends enough is to compare R&D expenditures in "development time": that is, how does India fare today compared with other countries at a similar development level, and whether the Indian trajectory today will allow it to catch up with other countries.

8.11 Figure 2 plots R&D as a share of GDP against per capita GDP for a set of comparable countries. It shows that India was, at one point, spending more on R&D as percentage of GDP than countries like China at the same level of GDP per capita. As a lower middle-income country, it is not surprising that India's spending on R&D lags upper-middle income and high-income countries such as China, Israel, and the U.S. However, it currently underspends even relative to its income level.

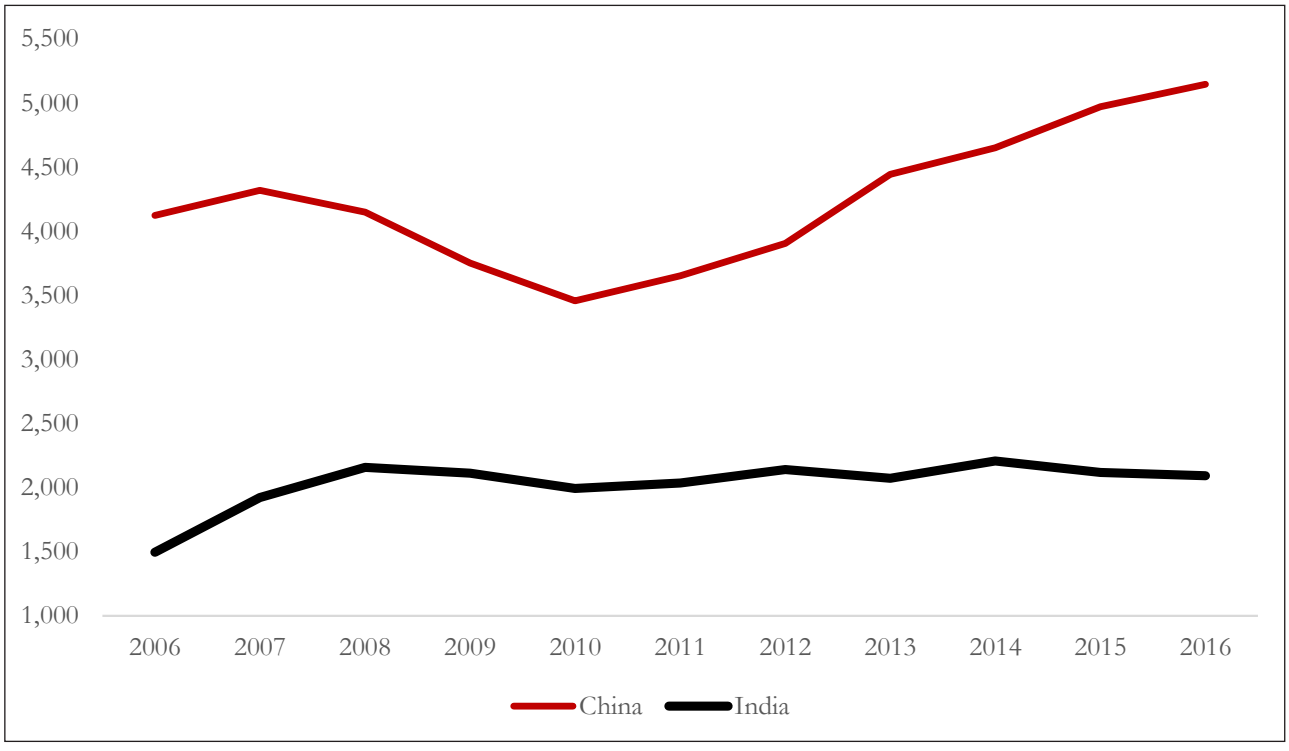
8.12 In addition, most other countries, especially East Asian countries like China, Japan, and Korea, have seen dramatic increases in R&D as a percentage of GDP as they have become richer. India, on the other hand, has only seen a slight increase. In fact, in 2015, there was a sizeable

Figure 2. R&D Expenditure as a Percentage of GDP (Development Time)



Source: UNESCO, World Economic Outlook (WEO), National Science Foundation(NSF).

Figure 3. Indian and Chinese PhDs in STEM in the US



Source: National Science Foundation

decline in R&D spending even as GDP per capita continued to rise. At its current rate, India would just barely reach GERD of 1 percent of GDP by the time it was as rich as the USA.

Ph.Ds. in Science, Technology, Engineering, and Mathematics (STEM)

8.13 The other critical input for R&D is a well-trained workforce among which Ph.D. students play an especially important role. Indian Ph.D. students obtain their degrees either within India or abroad, especially in the US. There are less than half as many Ph.D. students in STEM from India in the US as from China (figure 3). It appears that fewer Indian students have been enrolling in recent years for such degrees, whether due to more attractive options after a master's degree or rising work visa challenges.

Table 3. Investments in R&D, 2015

	U.S.A	ISRAEL	CHINA	INDIA
R&D Spending (PPP Billion Dollars)	479	12.2	371	48.1
Of which				
- Business	341	10.3	286	17
- Government	54	0.2	59	29
- Universities	64	1.5	26	2
- Private NP	20	0.1	--	--
R&D Spending (% of GDP)	2.8	4.3	2	0.8
Researchers per million population	4,231	8,255	1,113	156

Source: UNESCO

8.14 On the other hand, there has been an increase in Ph.D. enrollments in India. In 2015-16 126,451 students were enrolled in Ph.D. programs in India, of which 62 percent were in STEM fields (AISHE 2015-16). This increase is in part the result of concerted efforts by the government, including a substantial increase in the number and quantum of fellowships (such as the Prime Minister Research Fellowships at the IITs). Overall, though, India has far fewer researchers than other countries (Table 3).

OUTPUTS

Publications

8.15 Looking at publications and patents in India can help assess the productivity and quality of Indian research. In 2013, India ranked 6th in the world in scientific publications. Its ranking has been increasing as well. Between 2009-2014, annual publication growth was almost 14 percent. This increased India's share in global publications from 3.1 percent in 2009 to 4.4 percent in 2014 as per the Scopus Database.

8.16 Broadly, the publication trends reveal that India is gradually improving its performance as measured by an important metric – publications. However, there is a downside to the increase in publications. There are many journals that publish non- peer-reviewed manuscripts for a substantial fee. The major catalyst for their explosive growth is "the demand created by increasing emphasis on the number of research publications as an important determinant of the academic performance of a faculty/ scientist being considered for appointment or promotion"(Lakhotia, 2017).

8.17 But in addition to increasing publications, trends in quality (as measured by highly cited articles in table 3) are also slowly improving. The Nature Index (which publishes tables based on counts of high-quality research outputs in the previous calendar year covering the natural sciences) – ranked India at 13 in 2017. But there is still a considerable lag in levels between India and the other two large countries, and the rate of improvement in China between 2001 and 2011 is dramatically better than India's (table 4).

Patents

8.18 If journal publications reflect a country's prowess in science, patents reflect its standing in technology. According to the WIPO, India is the 7th largest Patent Filing Office in the World. In 2015, India registered 45,658 patents in comparison to China (1,101,864), USA (589,410), Japan (318,721), Republic of Korea (213,694), and Germany (91,726). However, India produces fewer patents per capita (Figure 4).

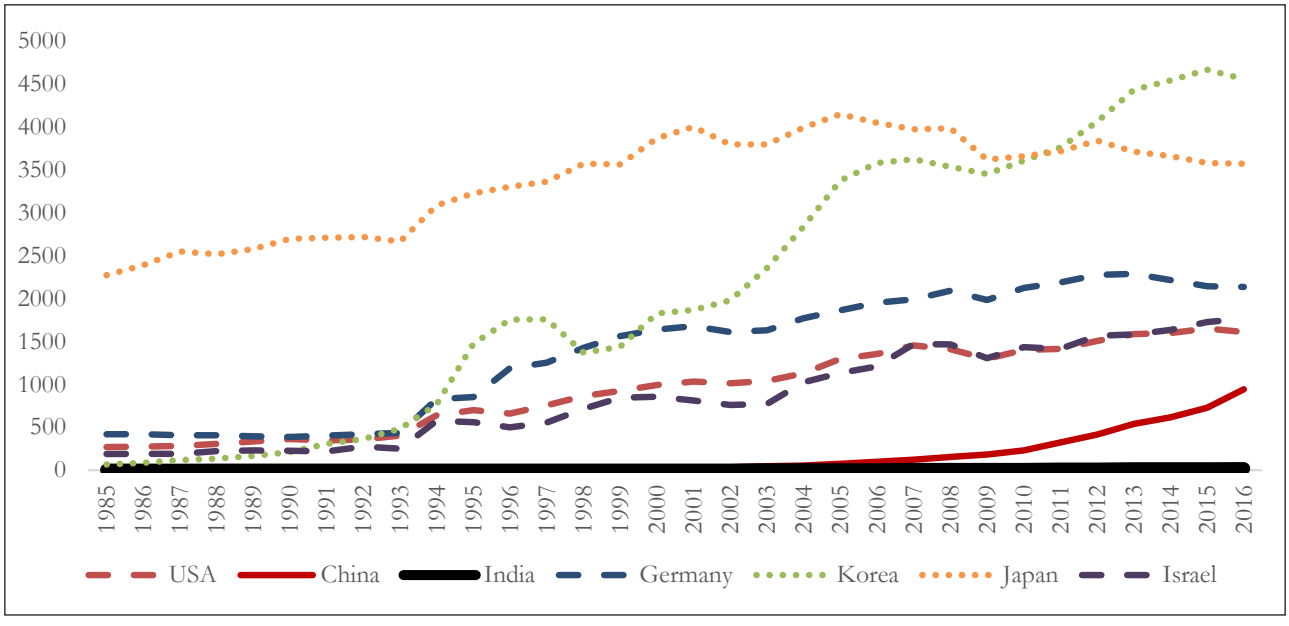
8.19 Even in development time, the story is mixed. On one hand, much of India's low patent output could be due to its lower middle-income status. However, patents have grown much faster with income in countries like China, Korea, and Japan (Figure 5). Unless there is a greater focus on R&D, rising income alone will not allow India to catch up in the near future.

Table 4. Publication Output Trends in China, India, and USA

YEAR	CHINA		INDIA		UNITED STATES	
	No. of publications	No. of highly cited articles	No. of publications	No. of highly cited articles	No. of publications	No. of highly cited articles
1990	6,104		12,346		130,559	
2001	25,730	174	15,522	103	150,817	2894
2011	122,672	980	36,456	191	184,253	3137

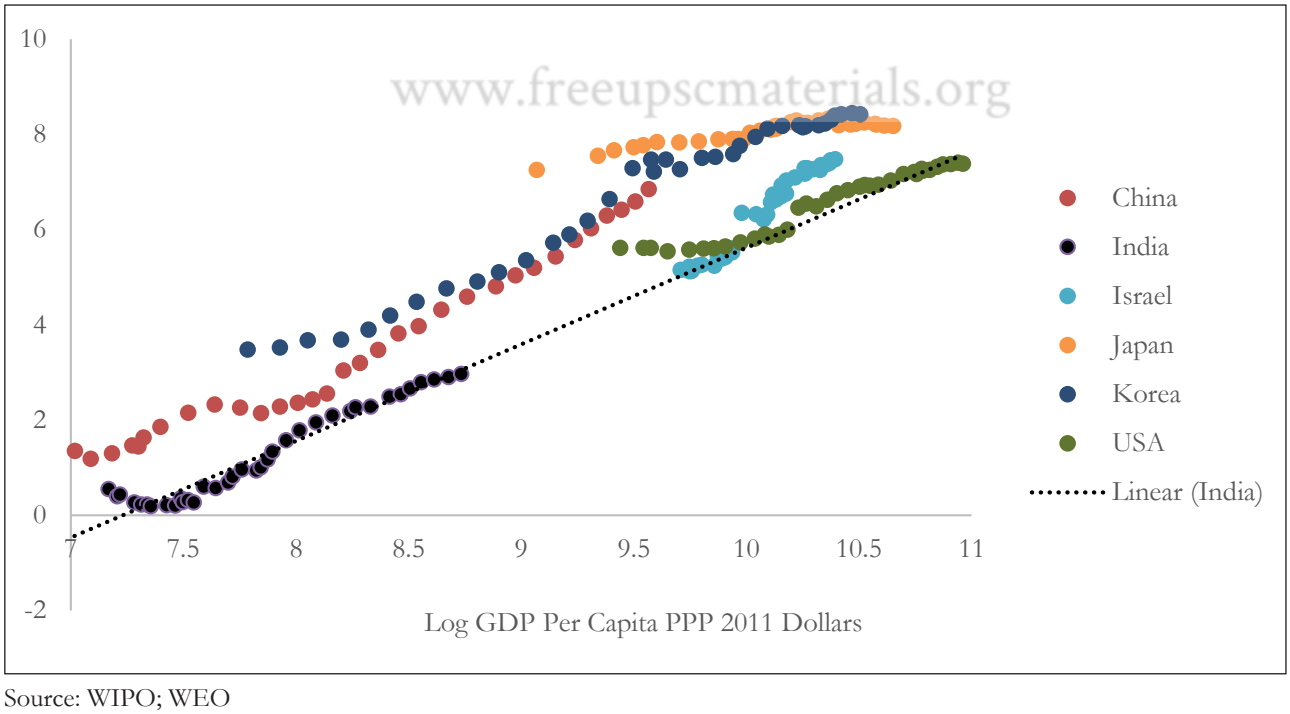
Source: Xiea (2014).

Figure 4. Patents Per 1 Million Population



Source: UNESCO

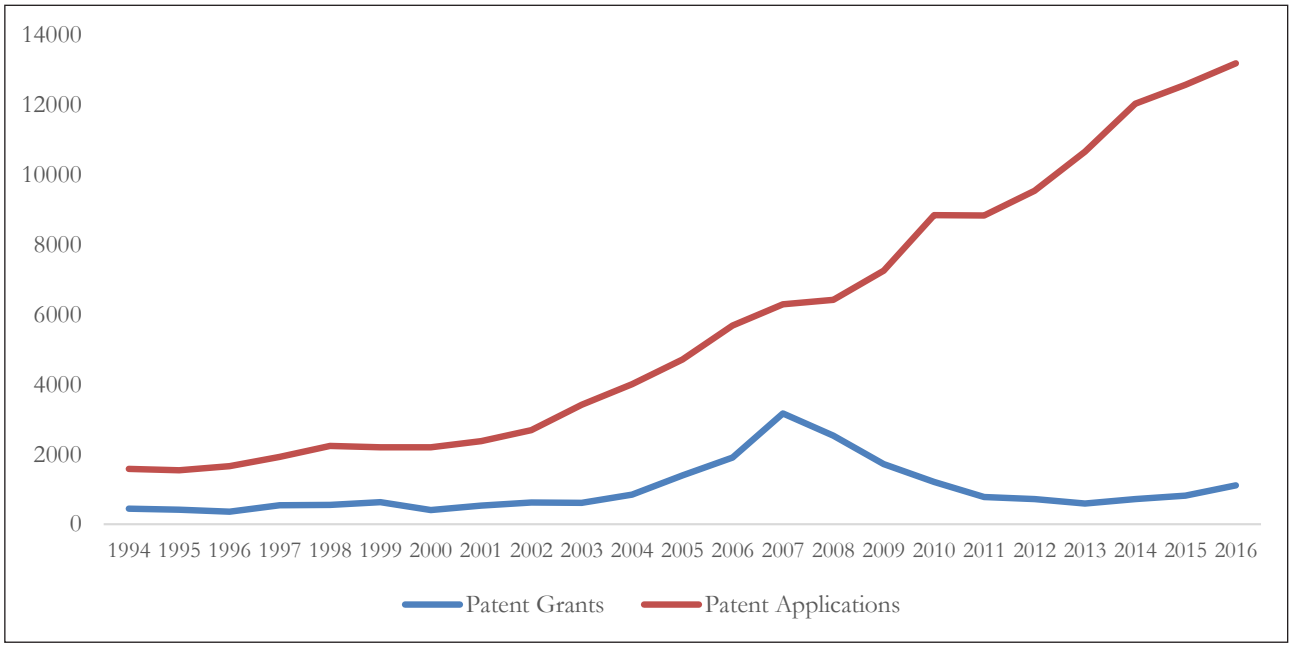
Figure 5. Log Total Patents Per 1 Million Population (Development Time)



Source: WIPO; WEO
Note: Applications from country residents in both domestic and foreign jurisdictions using equivalent counts as per WIPO

8.20 One major challenge in India has been the domestic patent system. While India's patent applications and grants have grown rapidly in foreign jurisdictions, the same is not true at home. Residential applications have increased substantially since India joined the international patent regime in 2005. However, the number of patents granted fell sharply post 2008 and has remained low (Figure 6). While Indian residents were granted over 5000 patents in foreign offices in 2015, the number for resident filings in India was little over 800.

Figure 6. Resident Patents Applied vs. Granted



Source: WIPO

8.21 The decrease in grants could have been due to a stricter examination process. But evidence suggests that there is a severe backlog and high rate of pendency for domestic patent applications. Reports indicate that due to manpower shortages there is a backlog of almost 2 lakh patents pending examination. In 2016-2017, there were only 132 examiners for all patent applications in India. This has meant that patent examination and granting can take 5 or more years (Chatterjee 2017). Given the rapid rate of technological obsolescence, the inordinate delays in processing patents penalizes innovation and innovators within the country.

8.22 The government's recent hiring of over 450 additional patent examiners and creation of an expedited filing system for Indian residents in 2017 will therefore be a welcome and crucial intervention to help fix the existing patent system (Jain 2017). Chapter 9 discusses the problems that pendency in patent litigation have had on innovation and business. Having addressed issues on the patent filing side, addressing patent litigation issues will also be crucial to ensuring that the patent system effectively rewards innovation.

EXPANDING R&D IN INDIA: THE WAY FORWARD

8.23 While the data discussed above presents a mixed view, many observers point to a more troubling picture. For example, a report submitted by a group of scientists has been quoted as saying: "The stature of Indian science is a shadow of what it used to be … because of decades of misguided interventions. We have lost self-confidence and ambition and the ability to recognize excellence amongst our own. In a false sense of egalitarianism, we often chose the mediocre at every level" (Koshy 2017).

8.24 Clearly, India needs to redouble its efforts to improve science and R&D in the country first and foremost by doubling national expenditures on R&D with most of the increase coming from the private sector and universities. But the metrics also need to go beyond papers and patents to a broader contribution to providing value for society. What might these efforts entail? Some ideas are discussed below:

I. Improve math and cognitive skills at the school level

8.25 No country can create a vibrant super-structure of R&D with weak foundations of primary and secondary education for so many of its young. While India has made considerable strides in improving access to primary and secondary education, as discussed in Chapter 5, learning outcomes have been weak. This weakness denies India access to the intellect and energies of millions of young people.

II. Encourage Investigator-led Research

8.26 India needs to gradually move to have a greater share of an investigator-driven model for funding science research. A step in this direction occurred in 2008, with the establishment of the Science and Engineering Research Board (SERB), a statutory body of DST. This body has sanctioned about three and half thousand new R&D projects to individual scientists. It is a promising start that needs to expand with more resources and creative governance structures.

III. Increase funding for research from private sector as well as from state governments

8.27 The private sector should be incentivized to both undertake more R&D but to also support STEM research through CSR funds. Current tax law already favors CSR investment into R&D, but the types of R&D activities eligible can be expanded. Government can also work with the private sector to create new R&D funding opportunities which are also in line with private sector interests. Efforts like the 50:50 partnership with SERB for industry relevant research under the Ucchatar Avishkar Yojana (UAY) is a good example of what could help make such partnerships fruitful.

8.28 State governments too need to recognize the need to invest in application oriented research aimed at problems specific to their economies and populations. This would both strengthen state universities as well as provide much needed knowledge in areas such as crops, ecology and species specific to a state.

IV. Link national labs to universities and create new knowledge eco-systems

8.29 The separation of research from teaching has been an Achilles heel for Indian science. Universities have students but need additional faculty support, while research institutes have qualified faculty but are starved of bright young students brimming with energy and ideas. A closer relationship between the two in specific geographic and spatial settings would help nurture research in areas reflecting the fields of science in which the national research centers have strengths. Together they can link up with the commercial sectors and help develop industrial clusters in those areas that draw on these research strengths and lay the foundations of innovation driven "smart cities."

8.30 If success in research requires a deep commitment to excellence, commercial success requires speed and nimbleness. Government rules such as those requiring L1 for procurement are simply not geared to providing the flexibility that is needed at the frontiers of research where speed, product quality and reliability make all the difference between success and failure.

V. Take a mission driven approach to R&D

8.31 India has the potential to be a global leader outright in a number of areas if it is willing to invest. However, this will require a deliberate focus in a few key areas. The potential missions given below were chosen for their strategic importance and potential for societal impact. This is an illustrative list which should be periodically revisited by the scientific community, government and other stakeholders.

A. National Mission on Dark Matter

8.32 India needs at least one mission that is directed towards the basic sciences. India is one of the leading countries in high energy physics and relevant mathematics. The payoffs from this research will have implications on space missions

of the future, quantum computing, newer solutions to energy problems etc. This mission can build on the strong foundation of astronomy and astrophysics research institutes in the country.[1] Furthermore, research in this area has some of the strongest international collaborative possibilities including those stemming from India's ongoing participation in the LIGO, Neutrino, CMS/LHC projects.

B. National Mission on Genomics

8.33 Genomic research lies at the heart of the future of the life sciences. Currently several countries have launched ambitious national genomic research projects e.g. UK Biobank Study; Finnish Birth Cohort Study; Partners HealthCare Bioban; China Kadoori Biobank. These studies are collecting detailed phenotype information, as well as blood and tissue samples, to study the determinants and life-course of biological pathways and disease. India already has a strong foundation of life science research institutes[2] which together can make significant contributions in this area.

C. National Mission on Energy Storage Systems

8.34 Renewable energy is the future and India has made a major commitment to investment in renewable energy. Energy storage technologies (e.g., batteries) help in energy management and power quality in electric power systems. India has lagged in manufacturing renewal energy generation systems. Substantial investments in energy storage systems will ensure that India can be a leader in manufacturing energy storage systems. For India, this will be especially helpful to provide round-the-clock electricity to villages using off-grid renewable energy systems.

D. National Mission on Mathematics

8.35 Mathematics has two special advantages for India: i) it is not capital intensive; ii) standards of excellence are universal. A National Mission of Mathematics will improve mathematics teaching at all levels of higher education, seek to establish five institutes of mathematical sciences within existing institutions, conduct annual district, state and national math Olympiad competitions with sizeable scholarships for all winners, with the overall goal of rapidly increasing India's human capital and research profile in mathematics within a decade.

E. National Mission on Cyber Physical Systems

8.36 The term Cyber Physical System (CPS) refers to machine based communication, analysis, inference, decision, action, and control in the context of a natural world ("Physical" aspect). This is hugely multidisciplinary area including deep mathematics used in Artificial Intelligence, Machine Learning, Big data Analytics, Block Chains, Expert Systems, Contextual Learning going to integration of all of these with intelligent materials and machines, control systems, sensors and actuators, robotics and smart manufacturing. Together these are the building blocks of future industry that will throw up both new challenges and opportunities.

F. National Mission on Agriculture

8.37 Improving Indian agricultural productivity, which still lags other countries such as China, as well as creating resilience to the looming challenges in terms of rising temperatures,

[1] These include the Indian Institute of Astrophysics (IIA), Bangalore; Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune; Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital; Tata Institute of Fundamental Research (TIFR), Mumbai; National Centre for Radio Astrophysics (NCRA-TIFR), Pune;Indian Institute of Science (IISc), Bangalore; Raman Research Institute (RRI), Bangalore; Physical Research Laboratory (PRL), Ahmedabad; Harish-Chandra Research Institute (HRI), Allahabad

[2] TIFR, IISc, IISERs, Center for Cellular and Molecular Biology, National Institute of Immunology, Institute of Genomics and Integrative Biology, National Center for Cell Science, National Center for Biological Sciences (NCBS) in Bangalore

variable precipitation, water scarcity, increase in pests and crop diseases requires a major thrust in agricultural science and technology. A national mission could help overcome the weaknesses in existing institutions of agricultural research and technology.

VI. Leverage scientific diaspora

8.38 There are today more than 100,000 people with PhDs, who were born in India but are now living and working outside India (more than 91,000 in the U.S. alone). From 2003 to 2013, while the number of scientists and engineers residing in the US rose from 21.6 million to 29 million, the number of immigrant scientists and engineers went from 3.4 million to 5.2 million. Of this, the number from India increased from just above half million in 2003 to 950,000 in 2013.

8.39 However, with the strength of India's economy and growing anti-immigrant atmosphere in some Western countries, India has an opportunity to attract back more scientists. There has been an increase in the number of Indian scientists returning to work in India during the last five years, but the numbers are still modest (from 243 during 2007-12 to 649 in 2012-17) (Press Trust of India 2017).

8.40 There are a number of government programs such as the Ramanujan Fellowship Scheme, the Innovation in Science Pursuit for Inspired Research (INSPIRE) Faculty Scheme and the Ramalingaswami Re-entry Fellowship, that provide avenues to qualified Indian researchers residing in foreign countries, to work in Indian institutes/universities, and the Visiting Advanced Joint Research Faculty Scheme (VAJRA). These schemes could be enhanced to take advantage of opportunities to recruit in a way to build whole research groups; the inducements should be such as to allow them to do good research (laboratory resources, ability to hire post-docs, housing etc.) rather than financial, to ensure that home grown talent has a level playing field.

VII. Improve the culture of research

8.41 Indian science and research institutes need to inculcate less hierarchical governance systems, that are less beholden to science administrators and encourage risk-taking and curiosity in the pursuit of excellence. While the age of peak productivity of scientists has shifted upwards over the 20th century, it is still less than fifty. Great achievements in the sciences decline after middle age, and youth, conceptual achievement, and scientific revolutions are linked (Jones et. al. 2014). Hence it is imperative that there be greater representation of younger scientists in decision-making bodies in their areas of expertise.

VIII. Greater public engagement of the science and research establishment

8.42 If science is to garner greater support from society, it will require scientists to engage more vigorously with society. Much of science is – and should be – a public good, and hence that will always require substantial public funding. But the need for publicly funded science means that national laboratories and other publicly funded R&D institutions need to make much stronger efforts to engage with the public and not make their research centers quintessential ivory towers. This will require much greater efforts at science communication whether through the media or through regular tours and lectures for school and college students as well the general public. Scientists need to create broad public support for their work and not treat it as an entitlement, given the many claims on the public purse. And if they do that, they will find a receptive and supportive public.

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Ease of Doing Business' Next Frontier: Timely Justice

09
CHAPTER

For who would bear the Whips and Scorns of time,
The Oppressor's wrong …
… the Law's delay

Hamlet

The government's efforts to make business and commerce easy have been widely acknowledged. The next frontier on the ease of doing business is addressing pendency, delays and backlogs in the appellate and judicial arenas. These are hampering dispute resolution and contract enforcement, discouraging investment, stalling projects, hampering tax collections but also stressing tax payers, and escalating legal costs. Coordinated action between government and the judiciary-- a kind of horizontal Cooperative Separation of Powers to complement vertical Cooperative Federalism between the central and state governments-- would address the "Law's delay" and boost economic activity.

INTRODUCTION

9.1 The now iconic scream of *Tarikh-par-Tarikh, Tarikh-par-Tarikh* ("dates followed by dates followed by dates") by Sunny Deol was Bollywood's counterpart to Shakespeare: two different expressional forms--the one loud and melodramatic, the other brooding and self-reflective--but both nevertheless united in forcefully articulating the frustrations of delayed-and-hence-denied justice.

9.2 India jumped thirty places to break into the top 100 for the first time in the World Bank's Ease of Doing Business Report (EODB), 2018. The rankings reflect the government's reform measures on a wide range of indicators. India leaped 53 and 33 spots in the taxation and insolvency indices, respectively, on the back of administrative reforms in taxation and passage of the Insolvency and Bankruptcy Code (IBC), 2016 (See Box No. 3.1 and 3.2 in Chapter 3 of Volume 2 of the *Economic Survey)*. It also made strides on protecting minority investors and obtaining credit, and retained a high rank on getting electricity, after a 70 spot rise in EODB, 2017 due to the government's electricity reforms. This year's report did not cover other measures such as the Goods and Services Tax (GST), which are expected to further boost India's ranking in the coming years.

9.3 This striking progress notwithstanding, India continues to lag on the indicator on enforcing contracts, marginally improving its position from 172 to 164 in the latest report, behind Pakistan, Congo and Sudan (See Annex I).

9.4 The importance of an effective, efficient and expeditious contract enforcement regime to economic growth and development cannot be overstated. A clear and certain legislative and executive regime backed by an efficient judiciary that fairly and punctually protects property rights, preserves sanctity of contracts, and enforces the rights and liabilities of parties is a prerequisite for business and commerce.[1]

[1] See North (1990); Engerman and Sokoloff (2000); Acemoglu, Johnson and Robinson (2001); Rodrik, Subramanian and Trebbi (2004); Acemoglu and Johnson (2005); La Porta et al. (1998, 1999); On India, see Kapur and Mehta (2007); Kapur, Mehta and Vaishnav (2017) and Chemin (2012).

9.5 The government has taken a number of actions to expedite and improve the contract enforcement regime. For example, the government: scrapped over 1000 redundant legislations; rationalized tribunals; amended The Arbitration and Conciliation Act, 2015; passed The Commercial Courts, Commercial Division and Commercial Appellate Division of High Courts Act, 2015; reduced intra-government litigation; and expanded the Lok Adalat Programme to reduce the burden on the judiciary. The government has also advanced a prospective legislative regime to ensure legal consistency, reducing chaos due to unpredictable changes in regulations. The judiciary has simultaneously expanded the seminal National Judicial Data Grid (NJDG) and is close to ensuring that every High Court of the country is digitized, an endeavor recognized in EODB, 2018. However, economic activity is being affected by the realities and long shadow of delays and pendency across the legal landscape. This chapter is a preliminary stab at quantitatively highlighting these developments based on new data that has been compiled for the *Economic Survey*.[2]

9.6 The finds are simple and stark :

(i) Delays and pendency[3] of economic cases are high and mounting in the Supreme Court, High Courts, Economic Tribunals, and Tax Department, which is taking a severe toll on the economy in terms of stalled projects, mounting legal costs, contested tax revenues, and reduced investment more broadly;

(ii) Delays and pendency stem from the increase in the overall workload of the judiciary, in turn due to expanding jurisdictions and the use of injunctions and stays; in the case of tax litigation, this stems from government persisting with litigation despite high rates of failure at every stage of the appellate process; and

(iii) Actions by the Courts and government acting together can considerably improve the situation.

PENDENCY AND DELAY: FACTS

Economic Tribunals

9.7 Analysis of six prominent appellate tribunals that deal exclusively with high stakes commercial matters reveal two patterns. First, there is a high level of pendency across the six tribunals, estimated at about 1.8 lakh cases (Figure 1). Second, pendency has risen sharply over time. As Figure 2 shows, nearly every tribunal started with manageable caseloads, disposing instituted cases every year, but that soon spiraled out of control. Compared to 2012, there is now a 25 percent increase in the size of unresolved cases. The average age of pending cases across these tribunals is 3.8 years. It is noteworthy that in two cases—telecommunications and electricity—the explosion in pendency resulted from interventions by the Supreme Court (See Annex II).

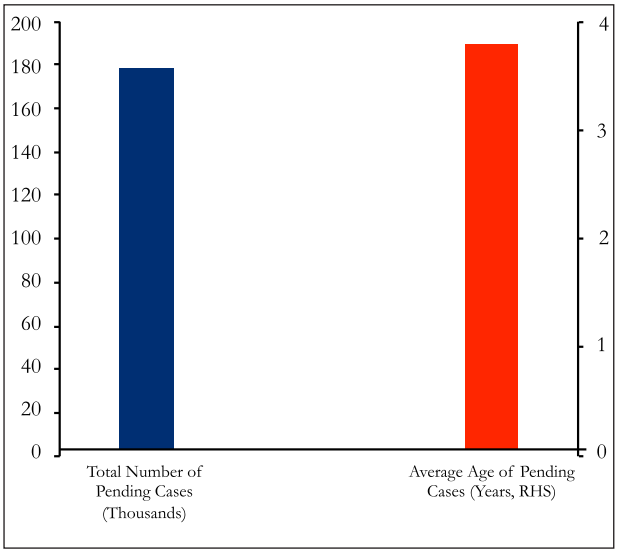
High Courts

9.8 Further, the creation of tribunals at different points in time did not alter pendency at the High Courts of the country nor their ability to deal with other economic cases. Three sets of economic cases pending at five High Courts were studied for the *Economic Survey*: company cases, arbitration cases and taxation cases. The overall pendency of the High Courts (Annex III), and the case-wise pendency of these economic cases at High Courts (Figure 4) continue to increase. The total backlog in High Courts by the end of 2017 as per the National Judicial Data Grid was close to 3.5 million cases. While the volume of economic cases is smaller than other case categories, their average duration of pendency is arguably the worst of most cases, nearly 4.3 years for 5 major High Courts. The average pendency of tax cases is particularly acute at nearly 6 years per case (Figures 3 and 4).

[2] The data relate to the Supreme Court, five of the major High Courts (Delhi, Madras, Bombay, Calcutta, and Allahabad), and six of the arguably most significant economic tribunals: telecommunications (Telecom Dispute Settlement and Appellate Tribunal- TDSAT), electricity (Appellate Tribunal for Electricity- APTEL), environment (National Green Tribunal- NGT), consumer protection (National Consumer Disputes Redressal Commission-NCDRC), central income tax (Income Tax Appellate Tribunal- ITAT), and central indirect taxes (Customs, Excise and Service Tax Appellate Tribunal-CESTAT).

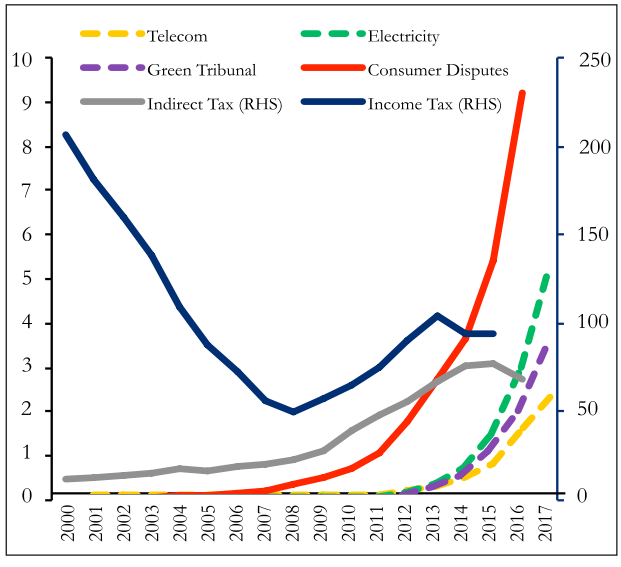
[3] For the purpose of this chapter, the expression "pendency" denotes all cases instituted but not disposed of, regardless of when the case was instituted. The chapter does not separately calculate the life of "delayed" cases i.e. a case that has been in the judicial system for longer than the normal life of a case (See Report No. 245 Arrears and Backlog: Creating Additional Judicial (wo)Manpower, Law Commission of India (2014).

Figure 1. Pending Cases: Stock (6 Appellate Tribunals, as on 31.10.2017)



Source: Data from 6 Appellate Tribunals and Daksh.

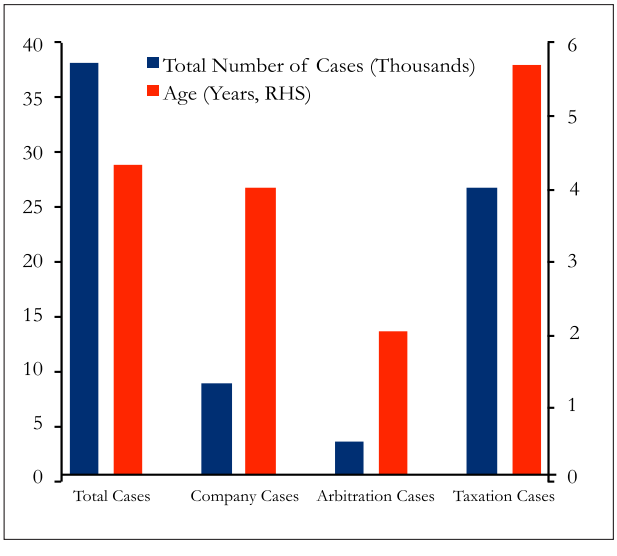
Figure 2. Pending Cases: Flow (6 Appellate Tribunals, 2000- 2017 in Thousands, as on 31.10.2017)



Source: Data from 6 Appellate Tribunals and Daksh.

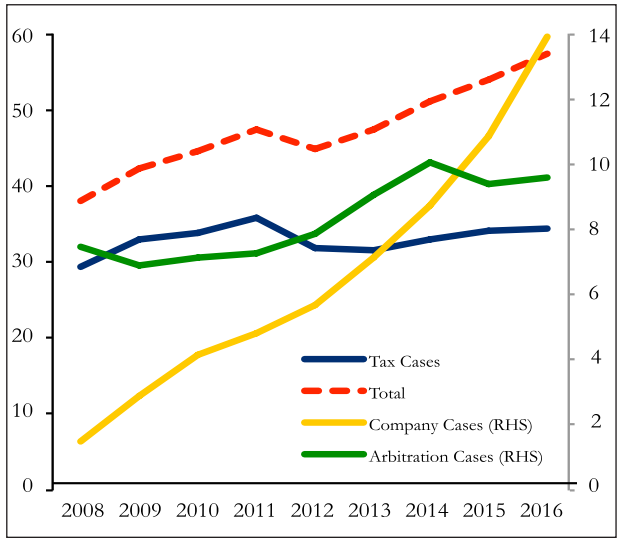
9.9 Reductions in pendency, if any, were achieved either due to changes in the counting methodology of pending cases, or due to changes in pecuniary jurisdictions that led to a mass transfer of cases from the original side of the High Courts to District Courts. After such changes, the new stock of pending cases continued to grow at previous, if not higher rates (See Annex III). Intervening measures like the setting up of the National Judicial Data Grid and creation of tribunals have helped, but more is needed to improve the situation.[4]

Figure 3. Pending Economic Cases: Stock (5 High Courts, as on 31.10.2017)



Source: Data from 5 High Courts and Daksh.

Figure 4. Pending Economic Cases: Flow (5 High Courts, 2008- 2016, in Thousands, as on 31.10.2017)



Source : Data from 5 High Courts.

[4] In the case of the Bombay High Court, which has a critical role to play in economic and commercial cases, total pendency has soared from 23 lakh cases in 1993 to nearly 41 lakh cases in 2016 (See Annex III).

PENDENCY AND DELAY: POSSIBLE REASONS

High Courts: Burden from Expansion of Discretionary Jurisdictions

9.10 One reason for the rising pendency of economic cases at the High Courts could simply be the generalized overload of cases. Further, economic and commercial cases are usually complex, require economic expertise in their handling and disposal, and hence, require more judicial time. In some instances, however, this increased overload is due to the expansion of discretionary jurisdictions by Courts, without any countervailing measures that either balance the scope of other jurisdictions or improve overall administration and efficiency.[5]

9.11 For example, Articles 226 and 227 of the Constitution of India empower High Courts with carefully circumscribed writ jurisdiction.[6] In practice, however, High Courts have permissively and expansively interpreted this provision over a period of time, which has resulted in a substantial increase in Article 226 cases.[7] There are currently one million Writ Petitions pending at the 6 High Courts studied, constituting between 50-60% of the Court backlog, with average pendency fluctuating between 3-10 years (See Annex IV). Data available for 2008- 2013 for 5 High Courts captures the continued rise in the pendency of Writ Petitions even in recent years, which is crowding out judicial time for other cases[8] (Annex V).

High Courts: Burden from Original Side Jurisdiction

9.12 Some High Courts of the country retain a unique original jurisdiction, under which the High Court, and not the relevant lower court, transforms into the Court of first instance for some civil cases.[9] These cases occupy a significant share of the Court's docket. The Delhi and Bombay High Courts have original jurisdictions that occupy nearly 10-15% of their workload (Annex VII). In 2014, the share of original side cases was as high as 30% for the Delhi High Court. Data compiled for the *Economic Survey* suggests that the High Courts take longer to clear civil suits as compared to their district court counterparts. The average pendency of civil suits at the Delhi High Court is 5.84 years, while that at the lower courts of Delhi is 3.66 years (Table 1).[10]

Table 1. Average Pendency of Civil Suits in Bombay and Delhi

Court Name	Pending Cases	Average Pendency (in years)
Delhi High Court	19,740	5.8
Delhi Lower Judiciary	15,223	3.7
Bombay High Court	16,099	6.1
Maharashtra Lower Judiciary*	1,02,931	5.6

Source: Daksh.

* Details unavailable for Greater Bombay cases which constitute original jurisdiction of Bombay High Court.

5. The higher judiciary has transformed into Courts of first rather than last resort, and have consistently fused constitutional law and tort law, dissolving traditional distinctions between public and private law. The immediate fallout of this expansion has been the steady de-legitimization of the capacity of lower courts' private law mechanisms (Balganesh, 2016).

6 The Supreme Court in 1958 limited this jurisdiction to seeing that courts and tribunals *"do not exercise their powers in excess of their statutory jurisdiction, but correctly administer the law within the ambit of the statute creating them or entrusting those functions to them"* (G. Verrappa Pillai v. Raman & Ramon Ltd, AIR 1952 SC 192). The Supreme Court warned against exercising appellate powers under writ jurisdiction, and held that *"so long as those Authorities function within the letter and spirit of the law, the High Court has no concern with the manner in which those powers have been exercised"* (Nagendra Nath Bora v. Commissioner of Hills Divisionand Appeals, Assam, AIR 1958 SC 398).

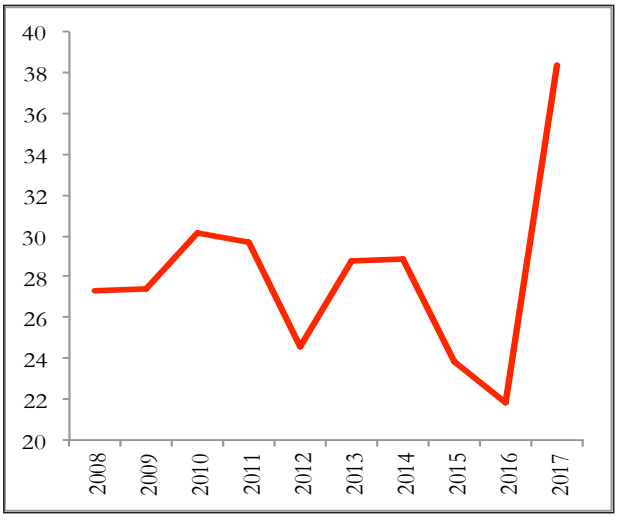
7 Several of these writ petitions pertain to administrative law, service law, taxation law, labour law, and orders of tribunals.

8 Annex VI captures the expansion of Writ Jurisdiction and criminal quashing jurisdiction over a longer period of time, from 1980- 2016, on the basis of the number of High Court judgments that rely on Article 226 of the Constitution of India and Section 482 of the Code of Criminal Procedure.

9 A Single Judge hears the cases; registrars conduct their trials; and an appeal from them lies before the Division Bench within the same High Court. The proportion of original side cases in these Courts has fluctuated with increases in pecuniary jurisdiction. For instance, in the case of the Delhi High Court, pecuniary jurisdiction was increased from 5 to 20 lakh in 2003, and from 20 lakh to 2 crores in 2016.

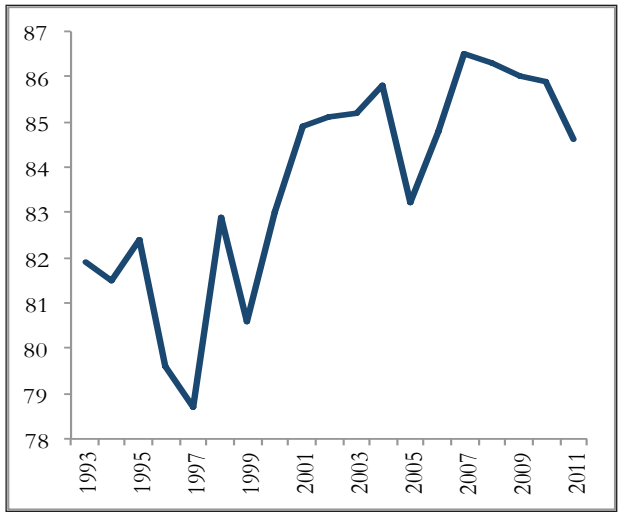
10 The Supreme Court of India is currently monitoring delays in disposal of civil suits by the High Court of Delhi in Re: Case Management of Original Suits Suo Moto Writ Petition (Civil) No. 8/2017. Pursuant to the said case, the High Court of Delhi notified the Delhi High Court (Original Side) Rules, 2018, due to come in force on March 1, 2018.

Figure 5. Percentage Share of cases in which SC Granted Leave



Source: Supreme Court of India.

Figure 6. Percentage Share of SLP Jurisdiction in SC's Admission Docket



Source: Supreme Court of India and Robinson (2013).

Supreme Court: Expansion of Special Leave Petition (SLP) Jurisdiction

9.13 The Supreme Court, like the High Courts, has less capacity to deal with mounting economic cases because of rising overall pendency (See Annex VIII). In the case of the SC, the burden derives in part from Special Leave Petitions under Article 136 of the Constitution of India, which empowers any party to approach the Supreme Court directly from any court or tribunal. Initially invoked only in "exceptional circumstances", SLPs are now an overwhelming feature of practice at the Supreme Court.[11]

9.14 As Figure 5 shows, the rate at which the Supreme Court admits Special Leave Petitions under Article 136 of the Constitution increased from around 25% in 2008 to nearly 40% in 2016. In contrast, the Supreme Court of the United States of America and Canada admit 3% and 9% respectively of the cases filed before it (See Annex IX). This rising tendency to grant special leave has fundamentally altered the nature of the Court and created a high level of pendency, nearly 85% of which are SLP cases (Figure 6).[12] The Court's SLP jurisdiction does not include other cases like transfer and review petitions, each of which occupies nearly 4-6% of the Court's docket (Annex X)[13]. Simultaneously, the share of writ cases has gone down from 7% in 1993 to under 2% in 2011.[14]

[11] In 1950, the Court observed that it would *"not grant special leave, unless it is shown that exceptional and special circumstances exist, that substantial and grave injustice has been done and that the case in question presents features of sufficient gravity to warrant a review of the decision appealed against"* (Pritam Singh v. State, 1950 SCR 453; AIR 1950 SC 169). This high standard has been relaxed over decades, leading the Court to observe in 2004 that *"in spite of the clear constitutional overtones that the jurisdiction is intended to settle the law so as to enable the High Courts and the courts subordinate to follow the principles of law propounded and settled by this Court and that this Court was not meant for redeeming injustice in individual cases, experience shows that such self-imposed restrictions placed as fetters on its own discretionary power under Article 136 have not hindered the Court from leaping into resolution of individual controversies"* (Jamshed Hormusji Wadia v. Board of Trustes, Port of Mumbai (2004) 3 SCC 214).

[12] A Division Bench of the Supreme Court of India in Mathai @ Joby v George (2016) 7 SCC 700 had referred a case to a constitution bench to review the criterion for granting leave under Article 136 to reverse its transformation into a regular appellate court. However, on January 11 2016, a five-Judge constitution bench refused to reduce the scope of Article 136 either by issuing guidelines or by limiting the types of cases that could be granted special leave to appeal.

[13] Evidence also shows that this enhanced workload is largely from those with money, the government, and appellants geographically situated closer to New Delhi. (Robinson 2013).

[14] Interestingly, this precise concern of an increased SLP workload had been foreseen and debated during the Constituent Assembly Debates: *"The question of possible congestion of work in the Supreme Court has included many honourable Members to oppose the provisions of these amendments… The fear of creating a serious congestion in that Court and also the fear that we will have to employ more Judges to deal with those cases is behind this opposition. I submit, however, that this fear is unjustified. So far as the question of law is concerned, it is only a 'substantial question of law', which will enable a party successfully to obtain a certificate or special leave"* Constituent Assembly Debate dated 14th June 1949. The debates clarified that SLP jurisdiction would be invoked only in case of *"a serious breach of some principle in the administration of justice, or breach of certain principles which strike at the very root of administration of justice as between man and man."* In light of the relaxation of standards of access to SLP jurisdiction, it is perhaps time for the Court to reconsider the scope of Article 136 of the Constitution, and lay down criteria similar to the Australian Judiciary Act, 1903 or the US Supreme Court Rules, for the sake of curbing not just the pendency of economic and other cases at the Court, but for preserving its character as the highest constitutional court of the country.

Recourse to Injunctions and Stays

9.15 Rising pendency also results from the injunction of cases by Courts. For example, in the case of Intellectual Property Rights (IPR) cases shown in Table 2 below, injunctions have led to about 60 percent of cases being stayed, whose average pendency is 4.3 years.[15] Lengthy interim orders, ex parte ad interim stays, increasing rate of pendency of cases at final arguments, and few final judgments in IPR cases[16] are common traits of IPR practice across different High Courts. Nearly 50% of these cases are pending at the stage of pleadings, which is the stage at which parties are required to complete formal requirements before hearing (Annex XI and Annex XII). See Chapter 8 of the *Economic Survey* for details on delays and pendency in filing and grant of patents.

9.16 Another 12% of these cases are pending for final disposal. The average age of cases waiting for final judgment is inordinately high at 7.9 years, showing that more attention needs to be given to cases pending at the stage of final disposal (Figure 7).

PENDENCY AND DELAY: COSTS

Costs of delay

9.17 It is difficult to estimate the costs of pendency and delays. But some illustrative data are instructive in conveying a sense of potential magnitudes involved. Table 3 provides the number and value of government projects in six infrastructure ministries that are *currently* stayed by court injunctions, as well as the average duration of their stays. It does not include other central government projects or the multitude of state level projects that are similarly stalled by Court injunctions, nor past projects that suffered delays due to injunctions but were subsequently allowed to resume operations. The project costs (stocks) of stayed projects—at the time they were originally stayed—amounted close to 52,000 crores.

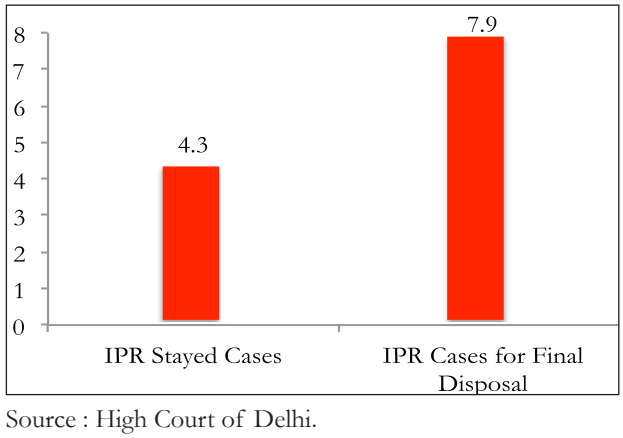
9.18 The Ministries of Power, Roads and Railways have been the hardest hit. Since project costs were predominantly debt-financed, it is likely that project costs have increased by close to 60 percent given the average duration of stay. Data collected from the State Bank of India (Table 4) revealed a similar picture for private sector infrastructure projects that sought extensions under Para 4.3.15.3 of an RBI Master circular due

Table 2. Pending IPR Cases- Stock (Delhi HC)

S. No.	Category	Total Cases	Stayed Cases	% of Stayed Cases
1.	Copyright	172	120	69.8%
2.	Patents	98	40	40.8%
3.	Trademarks	1219	704	57.8%
4.	Others	66	38	57.5%
	Total	**1555**	**902**	**58%**

Source : High Court of Delhi.

Figure 7. Average Age of Pending Cases-Stock (Stayed and Final Disposal IPR Cases, Delhi High Court, as on 31.10.2017)



Source : High Court of Delhi.

[15] The increasing tendency (See Annexure 10) to grant injunctions at the interim stage has fundamentally altered the nature of IPR litigation before the High Courts, which led the Supreme Court in a recent case to ask "if the High Court had thought it proper to write such an exhaustive (interim) judgment only because of acceptance of the fact that the interim orders in Intellectual Property Rights (IPR) matters in the Delhi High Court would govern the parties for a long duration of time and disposal of the main suit is a far cry." M/s AZ Tech (India) & Anr. v. M/s Intex Technologies (India) Ltd. & Anr.

[16] https://spicyip.com/2017/06/143-patent-infringement-lawsuits-between-2005-and-2015-only-5-judgments.html.

Table 3. Stayed Projects- Stock (6 Ministries, as on 31.10.2017)

Ministry	Stayed Projects	Total Value (Rs Crores)	Duration of Stay (Years)
Shipping	2	2620	5.9
Power	11	23,913	3
Road	30	11,216	3
Petroleum	2	342	0.9
Mines	12	106	4.5
Railways	12	13,882	3
Total	**52**	**52,081**	**4.3**

Source : Data from six Ministries.

Table 4. Projects Financed by SBI That Sought RBI Extensions- Last 3 Years

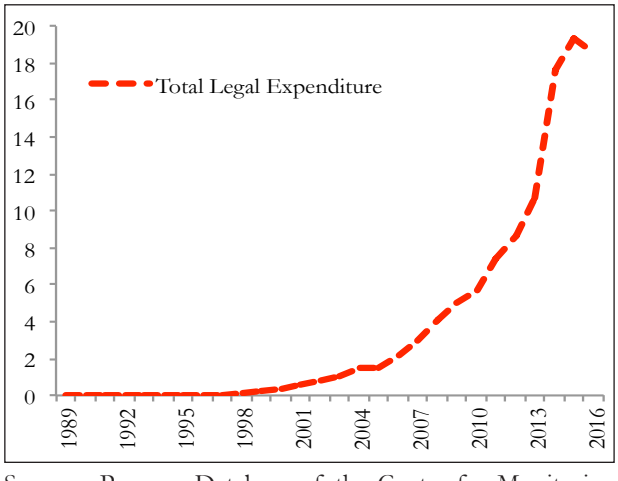
Total Number of Projects	Total Project Value (Rs Crores)	Number of Extensions Sought
11	33540	28

Source : State Bank of India.

to arbitration proceedings or court cases (Annex XIII).

9.19 The overall impact of rising pendency at Appellate Tribunals, High Courts and the Supreme Court, coupled with the rising use of injunctions and other blunt instruments has led to spiraling legal expenses of Corporate India, as shown in Figure 8.

Figure 8. Legal Expenses of Corporate India: Flow (1988- 2016, in thousand crores)



Source : Prowess Database of the Centre for Monitoring Indian Economy Pvt. Ltd. (CMIE).[17]

CENTRAL GOVERNMENT TAXES: A CASE STUDY

9.20 Pendency, arrears and delays are not just a feature of courts and tribunals, but also the Tax Departments and their multi-layered process.[18]

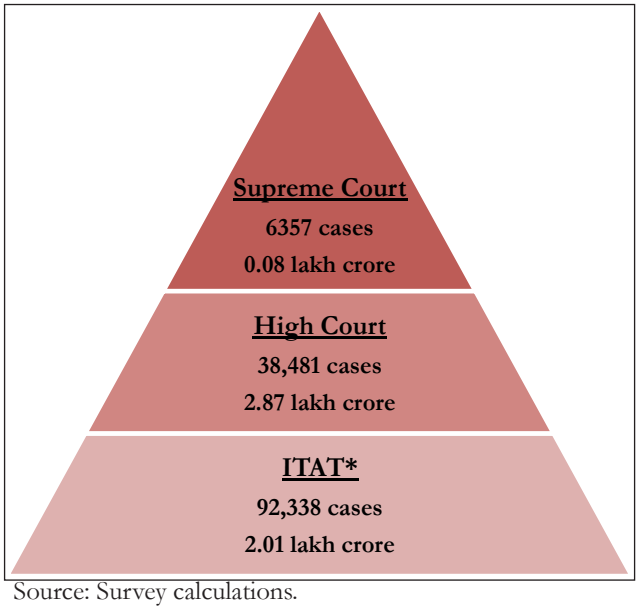
9.21 As of March 2017, there were approximately 1,37,176 direct tax cases under consideration at the level of ITAT, High Courts and Supreme Court (Figure 9). Just 0.2% of these cases constituted nearly 56% of the total demand value; and 66% of pending cases, each less than Rs. 10 lakhs in claim amount, added up to a mere 1.8% of the total locked-up value of pending cases.

9.22 The picture is not dissimilar in the case of indirect taxes shown in Figure 10. As of the quarter ending March 2017, a total of 1.45 lakh appeals were pending with the Commissioner (Appeals), CESTAT, HCs and the SC together, that were valued by the Department at 2.62 lakh crores. Together, the claims for indirect and

[17] Prowess is a database of the financial performance of over 27,000 companies. It includes all companies traded on the National Stock Exchange and the Bombay Stock Exchange, thousands of unlisted public limited companies and hundreds of private limited companies. It also includes a number of important business entities that are not registered companies.

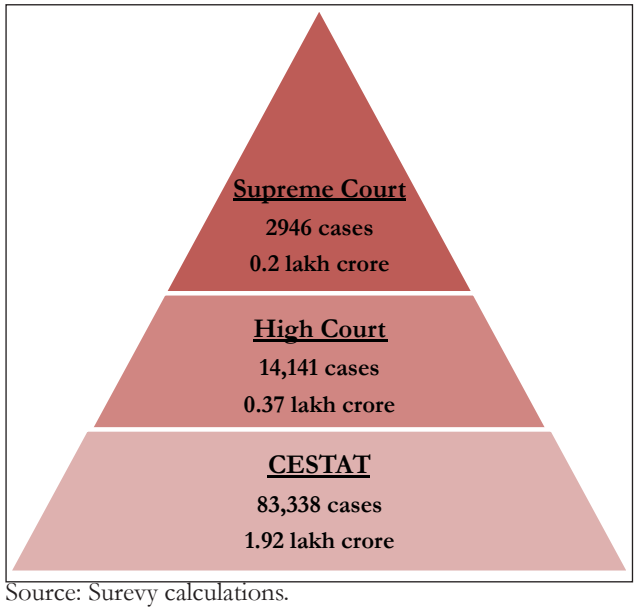
[18] After scrutiny, the Department or assesses have the option of approaching the Commissioner of Income Tax-Appeals (CIT-A), the Income Tax Appellate Tribunals (ITAT), the High Courts (HC) and finally the Supreme Court of India (SC). Similarly, in the case of indirect tax litigation, the Department and assesse have the option of approaching the Commissioner (Appeals), the Customs, Excise and Service Tax Appellate Tribunal (CESTAT), the High Courts and the Supreme Court of India.

Figure 9. Direct Taxes, as on 31.03.2017



Source: Survey calculations.

Figure 10. Indirect Taxes, as on 31.03.2017



Source: Surevy calculations.

* Provisional estimates.

direct tax stuck in litigation (Appellate Tribunal and upwards) by the quarter ending March, 2017 amounted to nearly 7.58 lakh crores, over 4.7 percent of GDP. For the Department, these numbers, especially the value of amounts involved have been rising sharply over time (See Annex XIV).

9.23 What is interesting is that the success rate of the Department at all three levels of appeal-- Appellate Tribunals, High Courts, and Supreme Court-- and for both direct and indirect tax litigation is under 30%. In some cases it is as low as 12% (See Table 5). The Department unambiguosuly loses 65% of its cases. Over a period of time, the success rate of the Department has only been declining, while that of the assessees has been increasing (Annex XV).

9.24 Nonetheless, the Department is the largest litigant. As Table 5 shows, the Department's appeals constitute nearly 85% of the total number of appeals filed in the case of direct taxes, though that number seems to have improved in the case of indirect taxes. Of the total number of direct tax cases pending by the quarter ending March, 2017, the Department initiated 88% of the litigation at ITATs and the Supreme Court and 83% of the litigation pending at High Courts.

9.25 The picture that emerges over a period of time is the following: even though the Department's

Table 5. Petition Rate and Success Rate of the Tax Department, as on 31.03.2017

	Direct Tax Cases		Indirect Tax Cases	
Court	**Success Rate[19]**	**Petition Rate[20]**	**Success Rate**	**Petition Rate**
Supreme Court	27%	87%	11%	63%
High Courts	13%	83%	46%	39%
ITAT/CESTAT	27%*	88%*	12%	20%

Source: Survey calculations. Source: Surevy calculations.

* Provisional estimates.

[19] The success rate of the Department is calculated as the proportion of cases in which the respective court or tribunal rules totally or partially in favour of the Department. Cases that are set aside by the judicial authority are excluded from this calculation.

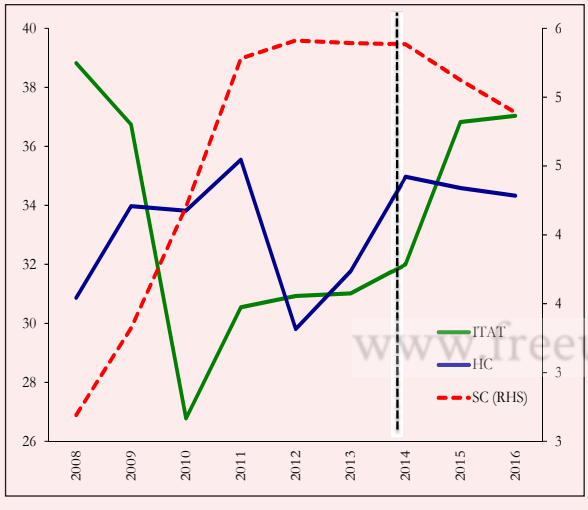
[20] The Petition Rate of the Department is the percentage of the total number of appeals filed by the Department. The remaining appeals are those filed by the assessees.

Box 1. Supreme Court's Successful Management of Tax Litigation

The Supreme Court is the highest court of the land that deals with a wide array of cases. When not dealing with substantial questions of law or constitutional issues requiring the constitution of special-sized benches, the Court sits in benches comprising of two judges to decide cases from High Courts and other forums of the country. The benches are expected to hear and decide cases from a wide range of subject matters inter alia constitutional law, criminal law, civil law, commercial law, and taxation.

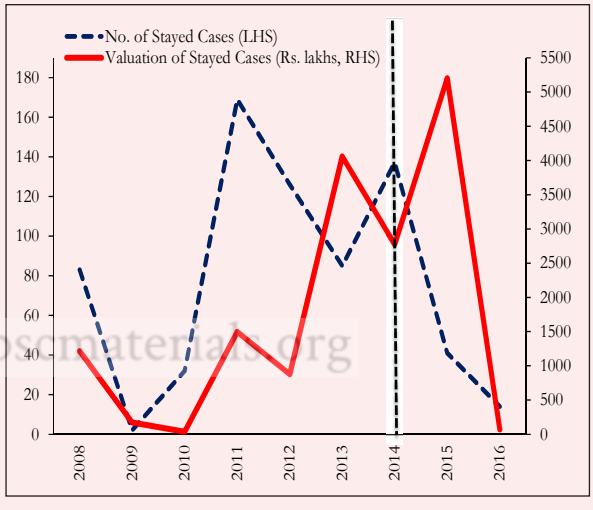
However, the Court's recent experiment with constituting an exclusive bench for taxation produced impressive results, which may be replicated for other subject matters, and emulated by other High Courts that do not have special rosters for daily hearings. Figure 1 shows that since the constitution of the tax bench in 2014, the Supreme Court has been able to reverse the trend of burgeoning pendency of tax cases. It is noteworthy that during this period, the SC reduced its reliance on staying claims of the Department, and focused on hearing and disposing cases, as evident from Figure 2.

Figure 1. Pendency of Tax Cases at ITAT, HC and Supreme Court (in thousands)



Source: Survey Calculations.

Figure 2. Details of Stayed Tax Cases in the Supreme Court



Source: Survey Calculations.

Besides reducing pendency and backlog, this phase of the Supreme Court saw a large number of judgments on law, and permitted the Court to discharge its envisaged role of clarifying and settling legal questions. The special bench authored 197 judgments in 2015, nearly three times as many passed in the previous three years.[1]

There are other profound benefits of dedicated subject- matter benches. Such benches ensure that the Supreme Court speaks in one voice, and there is continuity and consistency of legal jurisprudence. Further, they create efficiencies by allowing the judge to focus on the specialized branch of law placed before her. The model may be replicated for other commercial and economic areas of law as and when necessary at the Supreme Court, and should be replicated by every High Court of the country.

The Supreme Court's experience also confirms that Courts can take steps within existing design and capacity constraints to ameliorate pendency, particularly through specialized treatments of cases. For instance, there may be merit in handling different stages of cases also through specialized benches. Currently, most High Court judges hear cases in the following order: supplementary matters (new cases), advanced matters (admitted cases), and regular matters (cases listed for final disposal). Every judge starts the day with fresh cases, and reaches old cases only during the second half of the day, if at all. The experience of the SC's management indicates that it may be more prudent to create category-wise benches that exclusively deal with cases at the stage of final hearing for the entire working week, so that they are given the attention that the IPR data (Table 2) show are necessary.

[1] http://www.livemint.com/Politics/EFALB5X66jz0i2KkiE7WeL/The-apex-courts-tax-bench-experiment.html.

Table 6. Positions and Vacancies in High Courts and the Supreme Court

Total Number of Positions	No. of Vacancies	Vacancies as % o Total Capacity	Current Working Capacity
1079	392	36.3%	63.6%

Source: Ministry of Law and Justice.

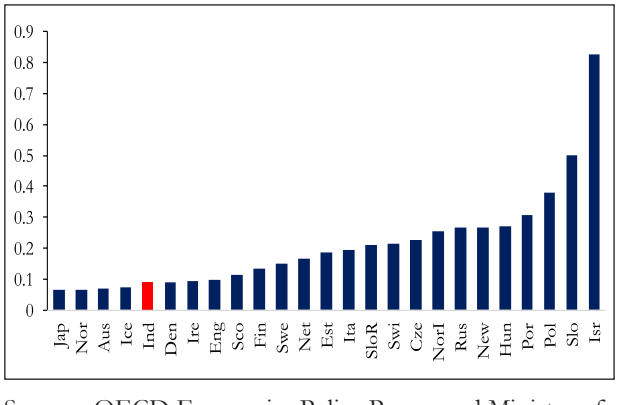
strike rate has been falling considerably over a period of time, it is undeterred, and persists in pursuing litigation at every level of the judicial hierarchy (See Annex XV and Annex XVI). Since tax litigation constitutes a large share of the workload of High Courts and the Supreme Court, Courts and the Department may gain from a reduction in appeals pursued at higher levels of the judiciary. Less might be more.

EXPENDITURE ON ADMINISTRATION OF JUSTICE

9.26 Total spending on Administration of Justice by States and the Centre constitutes approximately 0.08- 0.09% of GDP which is low when compared to other countries, especially common law countries (Figure 11). Research shows that while general spending on the judiciary may not impact pendency, spending on modernization, computerization and technology leads to shorter average trial lengths.[21]

9.27 The Government may consider including efforts and progress made in alleviating pendency

Figure 11 : Budget Allocated to Courts as a Percentage of GDP



Source : OECD Economics Policy Papers and Ministry of Finance.[22]

in the lower judiciary as a performance-based incentive for States. Further, expenditure may be prioritized for filing, service and other delivery related issues that tend to cause the maximum delays. Data compiled for the *Economic Survey* reveals that nearly 30% of a case's life is taken up by formal proceedings like service of summons and notices (See Annex XVII), issues that may be easily resolved through technological upgradation for filing and service mechanisms.

9.28 However, building additional judicial capacity may not be effective unless existing capacity is fully utilized. The higher judiciary is currently operating at 63.6% of existing capacity (Table 6). Experience from the 1990s confirms that increasing judicial capacity in the case of Income Tax Appellate Tribunals in the mid-1990s substantially reduced pendency (See Annex XVIII).

POLICY IMPLICATIONS

9.29 Pendency, delays and injunctions are overburdening courts and severely impacting the progress of cases, especially economic cases, through the different tiers of the appellate and judicial arenas. The Government and the Courts need to both work together for large-scale reforms and incremental improvements to combat a problem that is exacting a large toll from the economy. Some of the following steps may be considered:

(i) Expanding judicial capacity in the lower courts and reducing the existing burden on the High Courts and Supreme Court;

- For a smooth contract enforcement regime, it may be imperative to build capacity in the lower judiciary to particularly deal with

[21] Judicial performance and its determinants: a cross-country perspective, OECD Economic Policy Papers No. 5, June 2013.

[22] Jap- Japan, Nor- Norway, Aus- Australia, Ice- Iceland, Ind- India, Den- Denmark, Ire- Ireland, Eng- England and Wales, Sco- Scotland, Fin- Finland, Swe- Sweden, Net- Netherlands, Est- Estonia, Ita- Italy, SloR- Slovak Republic, Swi- Switzerland, Cze- Czech Republic, NorI- Northern Ireland, Rus- Russia, New- New Zealand, Hun- Hungary, Por- Portugal, Pol- Poland, Slo- Slovenia, Isr- Israel.

economic and commercial cases, and allow the High Courts to focus on streamlining and clarifying questions of law. For the same, amendments to the Code of Civil Procedure, Commercial Courts Act and other related commercial legislations should be considered (See Annex XIX). These measures must be buttressed by efforts to train judges, particularly in commercial and economic cases by judicial academies;

- Downsizing or removing original and commercial jurisdiction of High Courts, and enabling the lower judiciary to deal with such cases. Early results from the Delhi High Court suggest that reducing the size of original side jurisdiction in 2016 allowed the court more time to reduce its overall pendency (See Annex XX); [23]
- Courts may revisit the size and scale of their discretionary jurisdictions and avoid resorting to them unless necessary, to reclaim the envisaged constitutional and writ stature of the higher judiciary;
- Existing judicial capacity ought to be fully utilized.

(ii) The tax department exercising greater self-restraint by limiting appeals, given its low success rate. This could either take the form of *ex ante* rules limiting appeals, for example, to no more than one in four High Court verdicts or no more than one in three arbitration cases; or, given the long shadow of the 3 Cs (CBI, CVC, and CAG) in inducing bureaucratic risk-aversion, perhaps an independent Panel could be created to decide on further appeals of tax verdicts against the Department. Further, the number of tiers of scrutiny may be limited to three forums for taxation cases.

(iii) Substantially increasing state expenditure on the judiciary, particularly on their modernization. The Government may consider incentivizing expenditure on court modernization and digitization. This needs to be supported with greater provision of resources for both tribunals and courts. Moreover, legislations (and perhaps even judicial decisions that expand or introduce new jurisdictions) should be accompanied by judicial capacity and public expenditure memorandums, which adequately lay out the necessary provisions required to address increasing judicial requirements, and ensure their adequate funding. The amounts required may be negligible but the returns enormous;

(iv) Building on the success of the Supreme Court in disposing tax cases, creating more subject-matter and stage-specific benches that allow the Court to build internal specializations and efficiencies in combating pendency and delay;

(v) Reducing reliance on injunctions and stays. Courts may consider prioritizing stayed cases, and impose stricter timelines within which cases with temporary injunctions may be decided, especially when they involve government infrastructure projects; and

(vi) Improving the Courts Case Management and Court Automation Systems.[24] The EODB, 2018 identified specific issues with India's poor Court Management and Court Automation systems, which may be used as a template by Courts and the Government (See Annex XXI). To free up judicial time, initiatives like the Crown Court Management Services of the UK that are dedicated to the management and handling of administrative duties, may be considered.

9.30 Discussions that dominate public discourse about relations between the judiciary and other branches of government are to some extent moot. The point is not which side is right, but that the

[23] The government taskforce formed to discuss reform measures for ease of doing business noted: *"Measures introduced to streamline commercial disputes under the Commercial Courts Act has had nio impact on the indicator's data. As Mumbai and Delhi High Courts have original jurisdiction, commercial courts have not been established at the district level, rather commercial divisions of High Courts have been established. In this regard, the High Courts of Delhi and Mumbai are being consulted and inputs from the Department of Legal Affairs has been sought."*

[24] Devesh Kapur and Milan Vaishna, Strengthening India's Rule of Law http://www.livemint.com/Opinion/N3pY337lNutBRtXQs7GO3O/Strengthening-Indias-rule-of-law.html.

legitimacy and effectiveness of each depend on the lack thereof of the other. According to public perception, there is some Law of Constant Overall Legitimacy and Effectiveness, with one side's loss being the other's gain. However, this should probably give way to the Law of Mutually Reinforcing Legitimacy and Effectiveness. It is perhaps also true that the judiciary, especially the High Courts and Supreme Court, are still considered fair and final arbiters. The lament of increasing judicialization must contend with that perception.

9.31 Recent experience with the GST has shown that vertical cooperation between the center and states--Cooperative Federalism--has brought transformational economic policy changes. Perhaps there is a horizontal variant of that--one might call it the Cooperative Separation of Powers--that could be applied to the relationship between the judiciary on the one hand, and the executive/legislature on the other. There are, of course, clear lines of demarcation and separation of powers between the two to preserve independence and legitimacy. Even while respecting these lines, it should be possible and desirable for these branches to come together to ensure speedier justice to help overall economic activity.

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