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Socioeconomic Vulnerabilities of Migrant Labour Households in Delhi

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Abstract

The paper discusses the precarity of employment for vulnerable workers, and the laws and policies meant for protecting the interests of migrants. To provide a more complete picture of the migrants belonging to the marginalized and vulnerable sections, field work was carried out in two slums of Delhi to gauge their socioeconomic conditions, nature of employment, and living conditions. The employment structure in Delhi has also been examined, using secondary data, to gauge the pattern of informal employment. The figures reveal a very sordid picture, as a majority of the workers in Delhi do not have any social security or legal protection of their jobs, and work under terrible conditions. While the social security system has been expanded to cover informal workers, migrant workers are still excluded, as the institutional structure of these schemes is creating problems in being accessible to migrants. All these factors point towards the complete lack of visibility of migrants for decades from the policy framework. There is an urgent need to develop strategies that reduce the vulnerabilities of migrants in the cities and help alleviate their miseries.

Keywords: Migrants, Slumdwellers, Socioeconomic conditions, Vulnerabilities, Informal employment

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1. Introduction

Migration has been an integral part of the development process, particularly in large economies like India. However, the recent Covid pandemic brought to the fore the structural inadequacies in dealing with the problems encountered by low-skilled migrant workers. The vulnerability and insecurity of the migrant population during the pandemic revealed how the country's social protection system does not meet the requirements of migrant workers, who are a part of India's informal economy. It also highlights the need for putting in place sustained policy measures for generating robust data on migrant flows, understanding the characteristics of labour migration, and improving the access of migrant workers to social security schemes in order to maximise the developmental outcomes of migration.

In this context, this study attempts to show the social security issues for migrant labour households in Delhi, which is one of the major destinations for migrant workers in India. To understand the key concerns of the migrants, a field study was carried out in two slums of Delhi in 2018, to explore the living and working conditions of migrants, including their access to basic facilities and social security. Though the findings of the survey may not be easily generalised for all the slums in Delhi, they will help in examining the nature of employment, living conditions, and some of the major concerns of migrants living in the slums.

The main secondary data sources on internal migration in the country have been the Census of India and the National Sample Surveys. Additionally, the fourth annual report of the Periodic Labour Force Survey (PLFS) that was released on 14 June 2022 by the National Statistical Office (NSO) also gives data on the employment situation, and additional data on consumer expenditure and migration. This has been a key data source for migration, as the 64th round of the NSS and the Census 2011 data seemed to be outdated when there was a mass movement of migrant workers during the pandemic following the lockdown announced by the government.

Along with this, some private organisations also collected data on migrants, as there had been no official data collection on migrants till 2020 (Srivastav, 2022). The PLFS 2020-21 collected data on the reasons for migration, the impact of Covid on migrants, and also tried to differentiate between Covid-induced migrants and migrant workers.

The problem with Census and NSS data is that they are best suited to capture permanent migration, and hence underestimate labour mobility (Srivastava, 1998). Though the NSSO did try to collect data on short-term migration (by asking if any person was away for more than a month but less than six months), there were divergences in the macro data and field studies. Hence, due to lack of data, a lot of migration ends up being invisible.

Other than these sources, there have also been several micro studies of migration, such as the India Human Development Surveys (IHDS), Kerala migration surveys, etc. These help in understanding the volume and extent of internal migration. Many of these studies have reflected on the idea of social networks and raised questions on the inability of migrants to progress in the direction of upward

mobility (Rajan, 2020). Rajan (2020) highlights how most micro studies give an idea of the labour conditions, working conditions, wages, remittances, etc to better understand internal migration. But these micro studies have been limited to specific regions. In order to get a macro perspective of migration, there is a need to conduct regular migration surveys at an all-India level.

An analysis of migration trends in the country shows rising migration after 1991, with employment opportunities reducing in the rural areas. There has been a rise in the migration to urban areas that offer more economic opportunities, and a decline in the migration to rural areas. Between 1991-2011, approximately, 50 per cent male migrants from rural areas belonged to the prime working age group of 15-39 years, revealing a lack of avenues for work in the rural areas.

With economic opportunities improving after 1980s, the costs of migrating have been lower than the benefits or economic gains from migration. The Economic Survey of 2016-17 has highlighted how the rate of growth of labour migrants doubled, from 2.4% in 1991-2001 to 4.5% in 2001-11 based on Census estimates; meanwhile, workforce growth fell from 2.4% in 1991-2001 to 1.8% in 2001-11. Hence, the share of migrants in the workforce increased in 2001-11, compared to the previous decade.

In the case of Delhi as well, there was a rise in the migration in the period 1991-2001. Most male migrants come to Delhi in search of employment. A large percentage of the migrants to Delhi were from rural areas, though over time there was a rise in the proportion of migrants from other urban areas to Delhi. While 27.3% cent males migrated in search of employment in India as a whole, the corresponding figure for Delhi was 54.9% in Census 2011. As per Census 2011, 67% of the migrants who had come to Delhi to seek employment were from the states of U.P. and Bihar.

Rapid growth and development in Delhi has led to migration of people from rural, semi- rural areas, and urban areas into the secondary and tertiary sectors. The age profile of the migrants shows that 52.3% of the male migrants who arrived in Delhi in the period 2001-2011 were in the age group of 20-39 years. Also, a higher proportion of dependent population has been migrating to Delhi suggesting that people have not migrated out of distress. However, the high proportion of unemployed youth migrating to Delhi in the 1990s is a cause of concern, as it points towards the agrarian crisis facing the rural areas in the neo-liberal regime.

The employment trends in the country, and specifically in Delhi, show a sordid picture with a high level of informality of employment. The highly-urbanised nature of Delhi has put a lot of pressure on the civic infrastructure like water supply, solid waste management, sanitation, affordable housing, and services like health and educational facilities. According to Census 2011, 1.8 million people resided in slums in Delhi, which accounted for 10.6% of the population of NCT of Delhi.

Migration today is seen as a key factor contributing to urban surplus labour and urban unemployment problems. Though unemployment rates have decreased over time, these quantitative improvements do not signify an improvement in the quality of jobs as well. In some cases, decline in the unemployment rates could also be due to decline in labour force participation rates because of inadequate job creation and the 'discouraged worker effect'.

In poor economies, unemployment is not an option; they are often characterised by disguised unemployment or underemployment (Jha, 2016). Due to a dearth of opportunities in the formal sector, migrants join the informal sector, which consists of a wide range of activities. Informal sector workers earn low income, lack social security, and have limited possibilities of growth, forcing these workers to be stuck in menial jobs. However, it is difficult to ignore its role in enabling a substantial proportion of the population in escaping poverty, by providing them with a means of survival.

Migrants often face barriers in accessing housing, employment and other civic amenities (Bhagat, 2017). While it is true that migrants add to the presence of slums in the cities, it is also equally true that they have limited options for housing in the cities. Squatter settlements have now become a distinct feature of cities today. The slums in the cities are marked by squalor, overcrowded spaces, lack of water and sanitation facilities, poor housing, poor hygiene conditions, filth, and deprivation on many counts. Yet, these serve as the homes of people who are primarily engaged in informal work with limited social and job security.

Inclusive cities are an essential part of development agenda, to improve the socio-economic condition of citizens. Urban areas have been seen as investment hubs to improve the standard of living of the people residing there. Programmes like 'Make in India' and 'Skill India' are aimed at creating an increase in employment opportunities. However, there are deficits in infrastructure and sustainable development. Rapid urbanisation has led to a pressure on the dwindling civic amenities in the cities.

A substantial proportion of the migrant population in urban areas is attracted by economic opportunities, massive industrialisation, and better educational facilities in the metropolitan cities – which are already grappling with the problems of overcrowding. There is a need for inclusive political, institutions with state action to provide public goods such as universal education and healthcare, to reduce disparities or deprivations caused by inequalities. Socio-economic inequalities have increased, and there is a need to overhaul policies to serve the interests of the poor and marginalised.

The following sections of this paper are organised as follows: Section II is based on the field study, and examines the key concerns of the migrants in the slums with regard to their employment and living conditions. Section III discusses the precarity of employment for workers in Delhi. Section IV highlights the laws and policies meant for protecting the interests of migrant workers. Finally, the last section concludes the analysis by focusing on how Covid-19 affected the migrants in the country, and how vulnerable they were during the pandemic.

2. Inclusive Migrant Policies based on a Field Study in Delhi

In 2012, about 6,343 slums were in existence in urban Delhi, with approximately 10.2 lakh households residing in them (NSS, 2012-13). Approximately 29% of the slums had 20-60 households residing in them, and 71% slums had more than 60 households. The average households per slum was

161. Approximately 90% of the slums are on public land. As per Census 2011, 1.8 million persons – or 10.6% of the population of the NCT of Delhi – were living in slums.

Against this backdrop, and in order to provide a more complete picture of the migrants belonging to the marginalized and vulnerable sections in the NCT of Delhi, field work was carried out in June-November 2018 in two slums of Delhi, namely Kusumpur Pahari and Trilokpuri, using convenience sampling. The households chosen for the field survey were the ones where the head of the household was a migrant as defined by the 'place of birth' criterion of the Census. A total of 300 migrant households were interviewed, with 150 households selected at random from each of the two slums. Some of the key questions that were sought to be answered were regarding the socioeconomic conditions, the nature of employment, and living conditions of the migrants and their households.

The findings of the survey may not be representative of the entire slum population in the city, and cannot be generalised to represent all the migrant population in the city. In many cases, the findings in this survey may contradict some of the results of other studies. This is possible as the slums in Delhi are not homogenous; they differ in terms of the composition of their residents, their socio-economic profiles, and their problems. However, it does highlight some of the key concerns of the migrants living in the slums.

The typical migrant on arrival was young, and mostly compelled to migrate due to a paucity of employment opportunities in the rural areas. Informal networks helped rural migrants to access urban job market information. But the nature of employment of the migrants in the survey was primarily of a temporary nature. A majority of the slumdwellers did not receive the minimum wages as mandated by the government. They had little job security, and very limited scope for an improvement in their condition. Most of the migrant households in the slums were also found to live in miserable conditions, with limited access to basic amenities. Often, the migrants are excluded from various social welfare schemes of the government, due to a lack of residence proof, or a lack of awareness of the social welfare schemes.

2.1 Socioeconomic conditions

The socioeconomic characteristics that affect the wellbeing of the households are age composition, education, duration of migration, income of the household, and the availability of a token card (any form of recognised identity card). The surveyed slums have a relatively younger population group, and 96 percent of the heads of the households were in the 20-60 year age group, with a higher percentage of male than female migrants.

The higher number of males can be explained by the fact that it is primarily the male members who migrate, and the survey only covered migrant households. In some cases, only the male member migrates and stays in the city, while the spouse and other family members continue to reside in the rural areas. Longitudinal surveys in Bihar have revealed how most migration is circular, with the males migrating alone and aspiring to return to the villages after their working life.

In terms of education, 16% of the heads of the household in the survey were illiterate, and 60% had not passed the secondary level. The dismal education status of the heads of households in the slums gives an indication of the level of living of the people.

Income is one of the most important determinants of the socio-economic position of the migrant families. It is affected by several factors such as education levels of family members, nature of employment, years since they migrated, gender and age of the head of the household, caste, religion, number of dependent family members and the number of working members. There are variations in the level of income of the different migrants.

Another factor affecting the well-being of migrants is the duration of migration. There is a common notion that as the duration of migration increases, the migrants rise in the socio-economic ladder. While a study by Mitra (2006) has revealed an absence of a significant relationship between well-being and duration of migration, the field survey shows a significant value of the Chi-square statistic, indicating the presence of a significant relationship between the duration of migration and the level of per capita household income (

Table 1).

Table 1: Years of Migration and Average Household Per Capita Income (PCI)

Years of Migration	Number of households	Household PCI
0-1 years	2	1876.19
1-5 years	17	3458.33
5-10 years	30	4153.06
10-15 years	34	3508.33
Above 15 years	217	3905.15

Source: Field Survey

$\chi 2$=577.098, Significant, (p=0.000), p<0.05

The lowest PCI is of those households who migrated less than a year ago or less than five years ago. This can be explained by the fact that these households do not have secure employment, are mostly living in rented accommodations, do not have ration cards, and are not able to avail of the government's welfare schemes due to an absence of address proof.

Many migrants are excluded from various social welfare schemes of the government due to a lack of residence proof. Often, migrants do not have an address proof, which does not allow them to benefit from various schemes related to food security, free schooling, and cooking gas connections. Due to the importance of having identity proofs as a precondition to be a part of social sector schemes, the field survey asked migrants which documents they possessed for Delhi. It was observed in the field

survey that only 60 per cent of the migrants had a ration card of Delhi, 77.3 per cent had a voter card for Delhi and 86.7 per cent had an Aadhar card for Delhi.

It was found that often migrants faced problems in accessing the benefits provided to them under the National Food Security Act, 2013. It was observed in the field survey that only 60% of the migrants in the sample had access to subsidised food grains, while 21% were entitled to subsidised ration in their native places only, and 20% did not possess a ration card.

The One Nation, One Ration Card (ONORC) Scheme became operational in 2021. At the time of the survey in 2018, due to lack of PDS portability of benefits, migrants were unable to purchase subsidised ration in Delhi if they had ration cards from their native places. However, studies have shown that despite the ONORC scheme, technology failures at Fair Price Shops, fear of stockouts, and the unwillingness of PDS dealers to use any exception-handling mechanism in case of technology failure are some of the key reasons for denial of service (Nayak and Nehra, 2017).

The migrants who have recently moved into the city, and are living in most deplorable conditions are often the ones who are deprived of these benefits. To make ONORC more meaningful and inclusive, there is a need to create more awareness about the possibility of portability of benefits across states, and have technology upgradation for the PDS dealers.

2.2 Employment status of migrants

Employment is a key measure of the well-being of migrants, as it is a primary reason for their migration. There was a rise in the proportion of men migrating for employment, from 30% in Census 1991 to 37% in Census 2001 at the all-India level. However, this figure went down to 27% in Census 2011.

In the field survey, nearly 80% of the migrant heads of households had migrated in order to secure "Employment". More than 54% of the migrants in the field survey worked as farmers on their own land in rural areas prior to migration; another 20% were unemployed before migrating, indicating the lack of avenues for regular employment in rural areas. This explains why people choose to migrate to urban areas. While 37.3% of those who migrated more than 10 years ago were farmers before migrating, this number had increased to 58.8% for those who moved less than five years ago.

Table 2: Occupational Status before migration

Occupation Before Migration	Percentage
Farmer	54.3
Labour	20.3
Small Business	5.4
Unemployed	20
Total	100

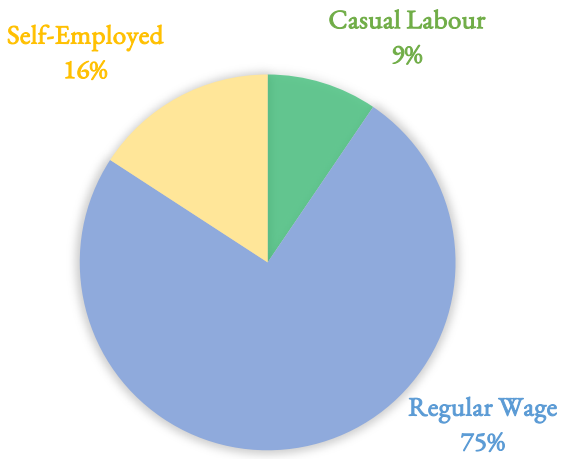
As per Thomas (2020), there has been a gradual movement away from agriculture, with young people being anxious to move away from rural areas. There was a fall in the employment in the agricultural and allied sectors (percentage of workers in agriculture and allied activities to total workers), from 64% in 1993 to 56.5% in 2004-05, 47.5% in 2011-12 based on NSS data, and 41.9% in 2017-18 as per PLFS.

Studies highlight how the construction and service sectors have been attracting people out of agriculture. One finds using data from various rounds of NSS and PLFS, that the share of construction in employment was 3.2% in 1993, 2.2% in 2005, and increased to 10.6% in 2011 and 11.6% in 2018. The manufacturing sector is increasingly becoming more capital intensive, and has not been able to provide a source of employment for people moving out of agriculture. Thomas (2020) has pointed out that, based on NSSO and Periodic Labour Force Survey (PLFS) data, the manufacturing employment declined from 61.3 million in 2011-12 to 60.3 million in 2017-18 (even as the overall size of the workforce and working-age population increased).

Concerns have been expressed about not only the high level of unemployment, but also the poor quality of employment, as a large proportion of the jobs created require low levels of skill and give commensurately low returns. Most of the employment is contractual, offering little job security to the workers.

In order to gather information about the employment status of each household member in the field survey, a six-fold classification was made. The categories were – casual labour, regular wage, self-employed, unemployed, student, and home-maker / voluntarily unemployed. Nearly 66% of the heads of the households were employed earning regular wages, 12% were working as casual labour, and 19% were self-employed. A smaller proportion were unemployed (0.7%) or voluntarily unemployed (1.3%).

Figure 1: Nature of Employment



Source: Field Survey

A substantial proportion of the migrants (75%) were employed as regular wage earners. Around 16% were self-employed, and only 9% worked as casual labour. However, a closer look at the working conditions is necessary to be able to understand the access to various social security measures.

Nearly 9% of the respondents to the survey worked as casual labour in various capacities, such as carpenter, painter, labour, mistry, etc. The working conditions of the casual labour in the field survey paints a very grim picture of their terms of employment.

- Approximately half (53.3%) of these workers visited the labour market on a regular basis;
- The average waiting time for a job was 2.22 days;
- 71% of them were working on an independent basis, without a contractor;
- All respondents who were working as casual labour earned daily wages; the average wages per day is a measly 413.33 rupees.
- Being a member of a trade union improves the bargaining position of the workers, however, none of the people working as casual labour were members of trade unions.

Table 3: Casual Labour profile

	Frequency
Visit labour market regularly	53.3%
Average waiting time	2.2 days
Working with a contractor	29%
Average daily wages	413.3 rupees
Average monthly wages	9789 rupees
Member of trade union	Nil

Source: Field Survey

A majority of the migrants receive regular wage or salaries. This is a broad category; it includes skilled, semi-skilled, and unskilled people employed in private organisations in various capacities, such as cooks, tailors, load pickers, peons, accountants, office assistants, office boys, data entry operators, and helpers in shops.

Out of 354 persons who worked as regular wage employees, 332 people were regularly employed, and 22 were contractually employed (**Table 4**). Though only 6% were contractually employed, approximately 90% of the sample could be removed from their jobs without any notice. This is an indication of the temporary nature of employment for a majority of the people, even those who receive regular wages.

Table 4: Regular Wage Employees Profile

Proportion of contractually employed	6%
Could be removed without notice	90%
Received bonus/extra payment	10.1%
Received pension/ PF/ Retirement benefits	16%

The category, 'Self-Employment' includes people working on their own. This broadly includes people employed in petty trade and vending, services, and transport. The self-employed operate their enterprises in different circumstances. While 56% operated their enterprise outside their homes and in the open air, 35% operated outside their homes but in closed surroundings, and 9% were operating from home.

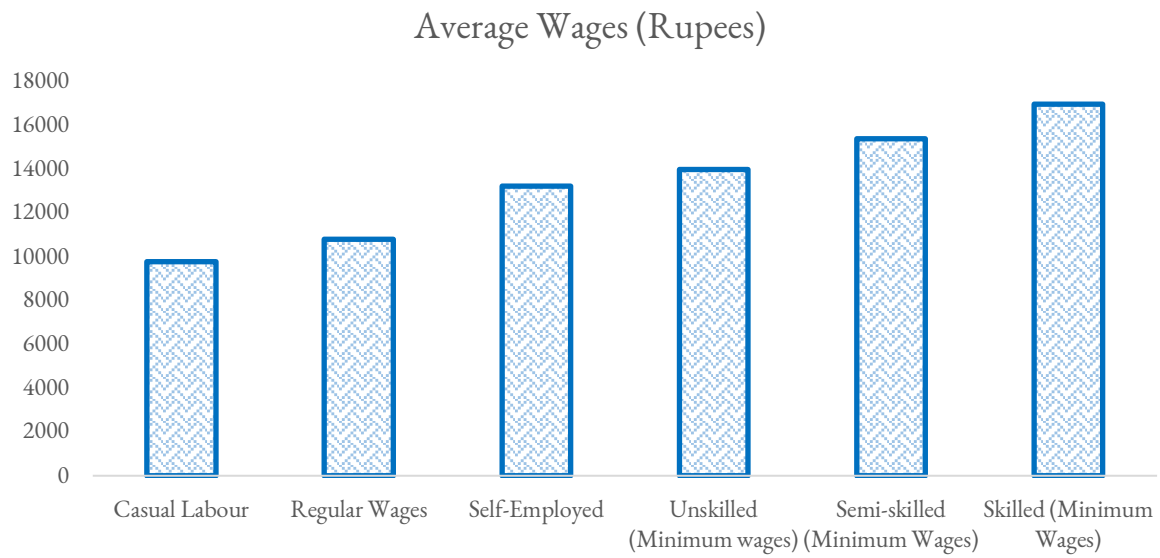
Often, the person involved in running the enterprise is assisted by other family members as well. They work in different capacities, such as employee or helper. Only 12% of the self-employed were a part of any trade union or workers' association that can help them in collective bargaining for their rights. These 12% are primarily auto drivers or taxi drivers.

Incidentally, none of the respondents who were self-employed were assisted by the government in any way in setting up their enterprise. This can also be understood when one sees that only 2 respondents were aware of skill training and credit societies under the Swarna Jayanti Shahari Rozgar Yojana (SJSRY). The unawareness of the people regarding the various employment assistance schemes of the government is the primary reason for people not being able to benefit from them.

It is important to make a comparison of the average wages earned in the different employment categories.

Figure 2 has made a comparison of the average wages earned by casual labour, regular wage employees, and self-employed persons. These have been compared with the minimum wages mandated by the Delhi Government. The minimum wages specified by the government vary depending on the skill level. It is evident that the average wages earned by each of the categories of labour are well below those mandated by the government, even for unskilled labour. This shows the disparity in income actually earned by people versus the mandated wages.

Figure 1: Comparison of Average Wages



Source: Field Survey; Labour Department, NCTD

The growth in post-1991 period has been largely jobless (Kannan *et al.,* 2009; Aggarwal, 2016) with only a few sectors experiencing employment growth with low employment elasticity, use of temporary and contract workers. While a majority of the migrants receive regular wages, they are employed in the informal sector, or informally employed in the formal sector. Informal workers are excluded from any kind of social protection and legal security that workers in the formal sector are entitled to. The wages and employment benefits of informal sector workers are much lower than formal sector workers.

Papola and Sharma (2015) have shown that, since 1991, there has been a tendency to employ contract workers instead of regular ones, as it is advantageous for the employers. Contract workers make production flexible as their numbers can be varied, they are not a part of labour unions, can be paid lower wages, and are not entitled to non-wage benefits that regular workers enjoy. Other field studies have also shown similar results about the level of informality of work in developing countries.

Middlemen often play an important role in mediating employment. Their role varies across the countries. A survey in developing countries like Nepal, Bangladesh, and India revealed the role of contractors or intermediaries due to the localized nature of the job market (Srivastava *et al.*, 2014). There were differences in the mode of payment of migrant workers who accessed employment through contractors.

3. Precarity of employment in Delhi

The glamourous lifestyle of Delhi attracts people, adding to the pressure on the service providers of health, water, housing and education. Delhi, which is mostly urban, has had a substantial manufacturing sector and retail sector growth. This has made it one of the favourite destinations for young adults looking for work, from all over the country.

At the beginning of the 20th century, the population of Delhi was a mere 0.2 million. After independence, there was a sudden rise in the population of Delhi when in 1951, the population crossed a million to reach 1.4 million. Since 1951, the population growth of Delhi has been very high, nearly doubling from 8.5 million in 1991 to 16.3 million in 2011, with 40% of them being migrants.

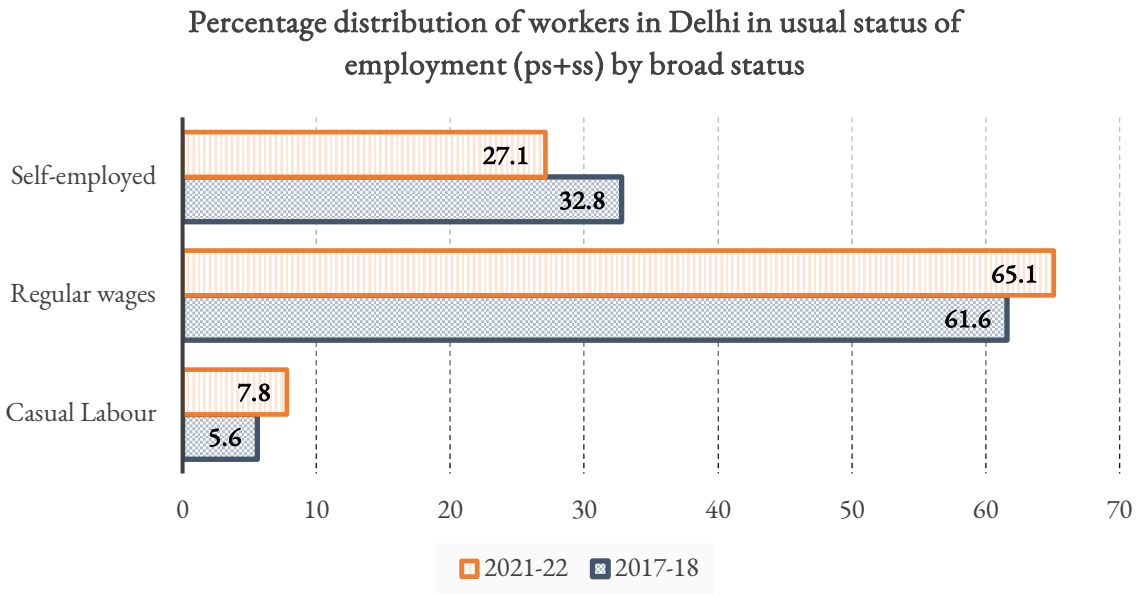
Approximately 12% of Delhi's population lives in slums (Census 2011). This figure is alarming, as Delhi has been contending as a smart city or a globalised metropolitan city. A survey by Das and Bhusan (2017) in 13 slums of Delhi revealed that 95% of the slumdwellers were migrants. Of the remaining 5% who were not migrants, it is said that though they were not first-generation migrants, their ancestors might have been migrants.

The employment structure in Delhi has been examined in this section based on the PLFS 2021-22 to gauge the pattern of employment for the workers in Delhi, as there is no specific data on the employment status of migrants in the city. The economic structure of Delhi has been largely based on the tertiary sector. As per the PLFS 2021-22, the tertiary sector accounted for providing employment to 60.2% of workers, followed by the secondary sector at 35.5% and the primary sector at 4.3%, according to the current weekly status by broad industry of work.

A comparison of the PLFS data for 2017-18 and 2021-22 based on the distribution of workers in usual status of employment (ps+ss) is explained in Figure 3, which reveals that there was a rise in the proportion of regular wage workers and casual labour, and a decline in the self-employed workers.

Despite a substantive proportion of the workers earning regular wages, the nature of their employment has been largely informal, with no security of tenure. In order to have an idea about the extent of informal employment among the workers in Delhi; data was collected as part of the PLFS on the conditions of employment of the regular wage workers in usual status (ps+ss) in the non-agricultural sector in 2017-18 and 2021-22. Information was collected on whether they had any written contract, paid leave or social security benefit.

Figure 2: Percentage distribution of workers in Delhi in usual status of employment (ps+ss) by broad status in 2017-18 and 2021-22



Source: PLFS, 2017-18 and 2021-22

Data revealed a very dismal state of workers when it comes to security of tenure, as revealed in Table 5. A matter of concern is the rising level of informality of employment in India. While there was a decline in the proportion of regular wage workers who did not have a written job contract, from 65.3% in 2017-18 to 46.8% in 2021-22, there was a rise in the proportion of workers who were not eligible for paid leave. There was a substantial rise in the workers who had no written job contract, were not eligible for paid leave, and did not have a social security benefit – from 31.6% to 45.7%.

The figures in the table reveal a very sordid picture for a majority of the workers in Delhi. A majority of the workers do not have any social security or legal protection of their jobs, and work under terrible conditions. Such workers suffer the most in the event of any economic crisis, as they are the first ones to lose their jobs. It is imperative to put in place a growth process that is based on the principles of equality and inclusivity in labour market outcomes. Some of the interventions need to focus on livelihood protection for a large mass of the population.

Table 5: Conditions of employment of regular wage workers in Delhi

	2017-18		2021-22	
	Males	Total	Males	Total
No written job contract (%)	66.9	65.3	42.4	46.8
Not eligible for paid leave (%)	44.8	44.6	44.8	48.9
Without any social security benefit (%)	57	56.7	52.8	55.9
Not eligible for paid leave, without written job contract and without any social security benefit (%)	31.5	31.6	41.1	45.7

Source: PLFS, 2017-18 and 2021-22

4. Laws and Policies for the Protection of Migrants

The migrant crisis during the Covid pandemic revealed how the country's social protection system does not meet the requirements of the migrant workers who are a part of India's informal economy. While social security systems have been expanded to cover informal workers, migrant workers are still excluded, as the institutional structure of these schemes is creating problems in being accessible to migrants (Srivastava, 2020).

This was prominent in the pandemic when the migrants were the worst affected in the country. Rajan (2020) points out that internal migration in India has been low, due to non-portability of benefits, and constraints on jobs because of domicility restrictions. It was only in 2019 that the government realized the need for 'One Nation, One Ration Card' to bring about ration card portability. All these factors point towards the complete lack of visibility of the migrants for decades from the policy framework.

Srivastava (2020) has pointed out that there are some fundamental issues regarding the implementation of the social protection programmes. They are primarily based on domicile, and are targeted for a certain section of the population. Also, the implementation of many of these programmes varies across the states.

Till recently, social security has been primarily limited to the formal sector. Though social security has been expanded to cover the informal sector, it is yet to reach the migrants, who remain neglected due to institutional barriers (Rajan *et al.*, 2020). Many provisions, which are available to in-state informal workers due to their domicile status, are not available to the migrant workers (Rajan, 2020).

Due to rising informality of work, many organisations are outside the purview of formal oversight structures. Hence, the workers are not protected by any social benefits or legislation. Many of the Acts are limited in their application. India has not yet become a signatory to ILO Convention No. 102, which guarantees social security benefits to all workers.

Most of the problems of the migrant workers in India are covered by law, as they are for other workers. However, implementation of most of the labour laws has been limited. There is only one law, namely, the Inter-State Migrant Workmen's Act (ISMWA), 1979 which was formulated to safeguard the interests of migrant workers and provide for their conditions of service.

The ISMW Act was enacted because it was felt that the Contract Labour Act did not adequately protect the interests of the workers. However, the Act is poorly implemented, as it only covers those migrant workers who came through a contractor. This definition is discriminatory, as it does not include in its purview those who left rural areas in a more distressed condition without a contractor, relying on informal contacts or kinship ties, which have a key role in helping migrants secure employment.

Similarly, only those who are formally employed are covered by the Act. However, many inter-state migrants are employed in petty economic activities or are self-employed. In all such cases, the ISMW Act is not applicable. Finally, this Act only covers inter-state migrants, leaving a significant proportion of the migrant population (who may be intra-state migrants) outside its purview. The field survey showed that none of the migrant heads of households came to Delhi through a contractor, and were thus outside the purview of the ISMW Act.

The enforcement of this Act and other labour protection laws lies with the union and state governments. However, enforcement of these laws has been limited, with most laws only being on paper. Often, there are no records of migrant workers, and the inspections carried out are also limited. There have also been gross violations of these laws in several cases.

Recently, the 44 labour laws have been proposed to be subsumed into four labour codes, with an aim to provide more flexibility to industries in employment. The government has hoped that through the Labour Codes, there would be more flexibility given to industries and an increase in the ease of doing business. Lawmakers have supported the demands of the employers in introducing the codes in the name of improving the ease of doing business and increasing investment by raising labour flexibility. However, this move has drawn criticism from several quarters, as it is felt that labour flexibility should be supplemented by universal social protection. The existing labour legislation needs to be strengthened by improving its enforcement, rather than legitimising labour cheapening.

5. Conclusion

There is primarily no social security net to address the problems faced by migrants at the places of destination. The lockdown showed the vulnerability of the urban poor, as they were the worst affected. Many of the informal migrant workers faced multiple hardships and had to even leave the city at a few hours' notice, as they were unable to bear basic living expenses such as rent and food. This highlights the need to develop strategies that reduce the vulnerabilities of the migrants in the cities and help alleviate their miseries.

A significant proportion of people are employed in the informal sector in India, and without any social protection. There is also a need to integrate migrant labour with local labour to ensure that they are paid the wages as per the minimum wage legislation. Though there have been several social security schemes by the government for the informal workers, they have achieved limited success.

People always migrate due to certain similar conditions like poverty, slavery, forced migration, war, expulsion, and labour demand caused by capitalist development. Often, labour migration is not only a response to labour scarcity, but a labour control strategy, which is a key feature of the development of capitalist accumulation.

In India as well, massive migration to the urban areas started with the development of modern enterprises. Capitalists prefer to use inter-state and intra-state migrant labour for better labour control, than surplus local labour. The poor living conditions of the migrants in urban areas, with no safety net, points at the inadequacies of migration in improving the well-being of the migrants. It ends up being a survival strategy for them, given their pauperisation in the places of origin. There is an urgent need to address the problems faced by migrants, by having a social security net for them at the places of destination.

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The Future of U.S.-India Private Sector Space Collaboration

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Abstract

India and the United States have dramatically deepened their cooperation on space exploration and technology in recent years. The two countries have codified their collaboration in the space domain through bilateral and multilateral agreements, including the U.S.-India initiative on Critical and Emerging Technology (iCET) and the Artemis Accords. At the same time, private companies are playing an increasingly prominent role in each country's civilian, military, and commercial space ambitions. While accounting for the differences in maturity and growth between each country's private space sector, this paper examines the barriers and incentives to collaboration between the Indian and American private space sectors. This paper's recommendations aim to guide policymakers from both countries in bridging their respective private sectors to advance mutual objectives.

Keywords: Space Policy, Innovation, Critical and Emerging Technologies, Commercial Space, Defence Cooperation, US-India Relations

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Introduction

Current US-India space collaboration marks a significant shift from their historical geopolitical dynamics, moving away from Cold War-era tensions. Over the past 25 years, their relationship has strengthened, driven by security interests, geopolitical imperatives, and technological advancements. Today, they collaborate on various fronts, including joint technological projects, defence, critical minerals, and space exploration. During Prime Minister Modi's June 2023 visit to the US, several joint initiatives were launched, and a vision for enhanced technology cooperation was outlined.

India's decision to join the Artemis Accords highlighted a significant departure from its traditional stance of strategic non-alignment. In a September 2023 joint statement, President Biden and Prime Minister Modi declared their intention to "forge ahead into new frontiers across all sectors of space cooperation," laying the groundwork for deeper collaboration in this strategic domain.

Advancing US-Indian cooperation in space requires further integrating the US and Indian commercial space sectors. Non-governmental actors, ranging from legacy companies to newly-formed startups, are increasingly shaping the trajectories of the Indian (and US) space sectors. When India initiated significant economic reforms in the early 1990s, it laid the preliminary groundwork for private sector involvement in the space sector. However, it wasn't until the last five years that a fundamental shift towards actual private sector participation in the space sector took place.

Once the country's first space startup emerged, the industry grew exponentially. According to Deloitte India and the Confederation of Indian Industry in their report, "NewSpace: India Perspective" (September 2023), India's space sector grew from one startup in 2014 to more than 190 startups in 2023. ISRO has reluctantly but obediently ceded to the private sector, opening new avenues for collaboration, both within and outside India, enabling US-India partnerships ranging from satellite development to space exploration missions.

However, joint innovation in space technology between the United States and India faces various challenges. The United States and Indian governments enforce strict export controls and maintain complex bureaucratic processes, which significantly impacts private-sector space collaboration. These controls restrict technology transfer and create substantial red tape, which, in turn, decreases the ease of conducting business in both countries' space sectors. This complex regulatory environment limits opportunities for cross-border investment and complicates the sharing of technology and expertise.

Additionally, the mature US space industry contrasts with India's developing space sector, posing challenges to effective collaboration. Lingering historical distrust and concerns over the other country's reliability on critical security and trade issues further compound these issues. For the US-India space partnership to become a significant space exploration and technology force, both nations would have to make concerted efforts to address these regulatory and trust-related challenges.

The core aim of our research is to address the following question: *How can the United States and Indian governments design incentives and reduce barriers to further integrate their space ecosystems, with a particular focus on their burgeoning private sectors?*

Using primary and secondary analysis and in-depth interviews with experts, we assess how each country's government and industry are approaching the prospect of collaboration in space technology. We also use field interviews and site visits with key industry stakeholders in Delhi and Bangalore to further understand the rapid growth of India's burgeoning private space sector and what this growth implies for the United States-India space relationship.

We divide our research and findings into four parts:

Part I contextualizes where US-India cooperation on defence and commercial space activities fits within the broader trajectory of the bilateral relationship. It traces the historical evolution and recent developments that have shaped this strategic partnership, setting the stage for deeper exploration of their collaborative efforts in space.

Part II offers an assessment of each country's space ecosystem, and maps their respective space value chains, highlighting their respective comparative advantages and identifying growth opportunities. This detailed examination underscores the significance of innovation and private sector participation in driving the future of space exploration and technology.

Part III discusses the institutional and regulatory barriers that hinder deeper space collaboration and ecosystem integration.

Part IV proposes policy recommendations for the US and Indian governments to further collaboration in the space sector. It discusses the mechanisms through which both governments can offer practical incentives for their private sectors to pursue joint ventures and collaborations. The section emphasizes the importance of navigating regulatory challenges, fostering technological exchanges, and cultivating a supportive ecosystem for collaborative innovation.

Part I: Historical Context and Changing Dynamics

1.1 Historical Context (1947-2013)

Since India's independence, the US-India relationship has evolved significantly. Prime Minister Nehru, India's first prime minister, aimed to keep India impartial during the Cold War. Despite initial challenges, India's non-alignment proved beneficial, as it received aid from both the US and the USSR. According to Arup Dasgupta's article "Charting Indo-US Space Cooperation" (2023), in 1969, ISRO collaborated with NASA on the SITE program, using a NASA satellite to broadcast educational programs to remote Indian villages.

India's non-aligned position was undermined by regional conflicts and shifting alliances. The United States' decision to support Pakistan during the Indo-Pakistani War of 1971, in its effort to counter the Soviet Union, strained the US-India relationship and fuelled mutual distrust. The US also opposed India's growing cooperation with the Soviet Union, including its purchase of Soviet weapons and extensive Soviet support for India's space program. In 1975, India launched its first satellite using a Soviet rocket (Weinraub 1975).

In 1998, India's Pokhran nuclear tests caused a significant strain in the US-India relationship (that had begun to improve after the Cold War). The Clinton administration imposed sanctions on India, which also affected its space program. This period marked a low point in bilateral relations. However, efforts to repair the relationship began in 2000, when President Clinton visited India, and continued under President Bush through diplomatic initiatives. Over time, sustained engagement, the lifting of sanctions, and growing mutual trust resulted in the 2005 US–India Civil Nuclear Agreement. This agreement paved the way for expanded cooperation, including in space. Following the nuclear deal, collaboration between the US and India increased, leading to joint projects in satellite technology, remote sensing, and space exploration.

In 2005, the countries also established the US-India Civil Space Joint Working Group (CSJWG), whose initial remit included areas from satellites to collaboration on Chandrayaan-1, India's first lunar probe mission (Embassy of India 2005, Department of State 2007). Chandrayaan-1 launched in 2008, and carried NASA's Moon Mineralogy Mapper; this was the first of many modern-era direct NASA and ISRO collaborations. Over the next five years, the US-India relationship and space collaboration improved, with regular CSJWG meetings and joint climate mapping from space. NASA also provided technical support for ISRO's 2013 Mangalyaan mission, India's first interplanetary mission.

1.2 Changing Dynamics and Recent Milestones (2014-Present)

The current era of US-India space collaboration began around 2014, coinciding with India's progress in space capabilities and the election of current Prime Minister Narendra Modi, who sought to deepen ties with the United States. Both countries saw China as a strategic adversary, leading to increased cooperation on sensitive technologies, including space and defence.

In 2014, the United States and India established the NASA-ISRO Mars Joint Working Group, and announced joint space initiatives. India's Mangalyaan Mars Orbiter Mission was a significant technological achievement, showcasing its rapidly advancing space capabilities. In 2020, the United States and India signalled interest in integrating their space sectors more comprehensively in their space policy objectives. Since 2021, the US and India have built and defined a shared vision for collaboration in space, elevating their partnership to a new height. Four initiatives mark essential steps forward in this collaboration: the Artemis Accords (common norms for space), INDUS-X (defence collaboration), Initiative on Critical and Emerging Technology (iCET) (critical technologies), and an enhanced NASA-ISRO relationship/CSJWG (increased traditional government-to-government space collaboration). In addition, deregulation has allowed private companies to develop advanced space technologies, altering the roles of governments.

The iCET and Artemis Accords are key pillars of US-India space collaboration. Launched in 2022, the iCET focuses on strategic technology partnerships, including innovation, defence tech, semiconductor supply chains, and space cooperation. It prioritizes human spaceflight, commercial

ventures, and talent exchanges in space science (The White House 2023a). The Artemis Accords, which India joined in 2023, set principles for peaceful, transparent, and responsible space exploration, emphasizing interoperability, emergency assistance, data sharing, and resource protection. India's alignment with Artemis Accords marks a significant shift in its space policy, a striking testament to how much the US-India space relationship has evolved since the Indian-Soviet space collaboration in the 1970s.

Bolstered by the foundations established by iCET and the Artemis accords, the India-US Defense Acceleration Ecosystem (INDUS-X) and upgraded NASA-ISRO/CSJWG collaboration could provide vehicles for both civilian and military space ecosystem integration. Launched in 2023 following the inaugural Defense Space Dialogue in 2022, INDUS-X operationalizes iCET's "Defence Innovation Bridge" (Press Information Bureau 2023). INDUS-X seeks to bring together government, the private sector, and academia into a single, more interconnected defence ecosystem through initiatives including mentor-protégé partnerships, standardizing certifications for technology companies, and easing regulations for cross-border development (Department of Defense 2023).

NASA-ISRO/CSJWG collaboration also contains a wide variety of new initiatives, including the creation of a sub-working group under CSJWG dedicated to commercial space collaboration and the NASA-ISRO Synthetic Aperture Radar (NISAR) mission, the first space hardware collaboration between NASA and ISRO on an Earth-observing mission (The White House 2023b, 2023c). The NISAR mission, set to launch in 2024, marks an important shift from consultative cooperation to concrete collaboration.

The United States and India have started the four aforementioned initiatives to build the foundation for stronger space cooperation. As the CSJWG has grown and matured since 2005, so will these new institutions, fuelling the current momentum behind U.S.-India space collaboration.

1.3 Private Sector's Rise in Space Innovation

In contrast to prominent government-led space programs of the twentieth century, the private sector has taken a leading role in space activities due to liberalization measures by major spacefaring nations like the US and India. As more private firms enter the space market, they focus on operational efficiency, reducing launch costs, and fostering rapid innovation. The dual-use nature of space assets means this growth has significant strategic and economic implications for spacefaring nations.

Moreover, the commercial sector has required less R&D investment as many technologies, particularly for satellite launches, have become standard. Present-day launch costs are 40 times lower than they were in the 1980s, and recent analysis by Citibank approximates that they will fall an additional 95% by 2040 due to reusability, scale, lower input costs, and cost-efficient production methods (Citi GPS 2022). As firms master efficiency in the space value chain, they will play a key role in innovating dual-use space assets, which are of strategic interest to countries like the US and India.

In the subsequent section, we will contextualize the role of private firms in the US and Indian space sectors. Then, we will assess how space market deregulation has impacted India's private space sector. Finally, we will highlight current and projected advantages within the Indian private space sector that US stakeholders should explore further.

Part II. Space Value Chain

2.1 Defining the Space Value Chain

The space value chain encompasses the complete spectrum of activities and services in the space industry. We divide the space value chain into three core segments: upstream, midstream, and downstream. Each of these segments has distinct roles and functions in the overall value-creation process:

- **Upstream activities** in the space industry focus on creating space equipment, such as satellites and spacecraft. This phase includes satellite manufacturing, which is essential for Earth observation and communication applications.
- **Midstream activities** in the space sector connect the manufacturing of spacecraft and satellites to their use in space. This category includes ground station operations for satellite launches, satellite operations, and managing space-based assets from Earth.
- **Downstream activities** focus on using data procured from space for terrestrial applications. This phase involves managing and processing data for end-uses like weather forecasting, agricultural monitoring, and disaster management.

Table 1: Comparative Matrix of Prominent US and Indian Firms Along the Space Value Chain

	United States	India
Upstream	**Blue Origin:** Human spaceflight services **Boeing:** Satellites, space vehicles **Lockheed Martin:** Aerospace, satellite launches **Northrop Grumman:** Aerospace, defence tech **Rocket Lab:** Commercial satellite launches **SpaceX:** Rocket and Space Launches	**AADYAH Aerospace:** Aerospace components, propulsion **Agnikul Cosmos:** On-demand satellite launches **Azitaa BST Aerospace:** Satellite tech services **Bellatrix Aerospace:** In-space propulsion, satellites **Dhruva Space:** On-demand satellite launches

		Skyroot Aerospace: Cost-effective launch vehicles **Multiple startups:** Small satellite design
Midstream	**Blue Origin:** Human spaceflight services **Globalstar, Inc:** Promotes, exploits space products **Iridium Communications:** Global satellite communications **OneWeb:** Broadband internet satellites **SpaceX Starlink:** High-speed internet satellites	**ISRO:** Ground station capabilities **New Space India Limited (NSIL):** Manages the production, assembly, and integration of launch vehicles with industry consortium
Downstream	**Google Earth:** Mapping with satellite imagery **GPS Navigation Systems:** Satellite nav. services **Virgin Galactic:** Space Tourism	**Astrogate Labs:** Optical satellite communication **Digantara:** Space situational awareness (SSA) **GalaxEye:** Space-based observation **Pixxel:** Hyperspectral earth observation satellites **Multiple startups:** Space data analysis and processing services

2.2 Key Players in The United States and India's Space Ecosystems

This section outlines the key institutional players that make up the United States and India's respective space ecosystems. We briefly summarize the evolution of each country's government, military, and private sector involvement in space activities until the present day and situate these actors in each country's present-day space value chains.

United States

Since the 1980s, private industry has played a key role in shaping the United States' space program. Large aerospace companies have traditionally been involved in government space missions; for instance, Boeing, Lockheed Martin, General Dynamics, and LTV have traditionally played vital roles in government space missions. Now, however, startups and small to medium-sized enterprises are also contributing significantly to the space economy by creating new market opportunities, and enhancing the supply chain in specific sectors such as satellite manufacturing, space tourism, and commercial launch services.

The United States leads in government space spending globally. Even so, in 2021, over 80% of the US space industry was made up of commercial entities, highlighting the substantial role of private enterprise (Zagorsky 2023). SpaceX, in particular, has made significant strides in reducing orbit costs with reusable rocket technology, making space missions more economical, and capturing a significant share of the global launch market (Weinzierl, Lucas, and Sarang 2020).

India

India's space aspirations, while following a different trajectory and pace, mirror the US goal of leveraging the private sector for commercial and strategic aims. Initially focused on national development, India's space efforts, led by ISRO, have recently shifted towards privatization and global integration with reforms like New Space India Limited (NSIL) and IN-SPACe. This shift aligns with global space commercialization trends, though ISRO remains a dominant player.

The Indian Government's Role in its Domestic Space Sector

India's space sector remained highly regulated until the late 2010s, leaving the private space sector with no room to flourish. For decades, the private sector in India's space economy consisted primarily of ISRO's Tier-2 and Tier-3 suppliers. ISRO had thus cultivated an expansive vendor ecosystem, with about 400 private companies operating in clusters near cities such as Bangalore, Hyderabad, and Pune. Such vendors tend to specialize in space-specific products like screws and sealants, and up to one hundred can collaborate on a single ISRO launch (Travelli 2023). Thus, India's private space sector could not evolve beyond ISRO's fragmented private vendor ecosystem until recently.

In 2019, under Prime Minister Modi, India's space sector saw a major shift, with privatization and new objectives guided by the Aatmanirbhar Bharat strategy promoting self-reliance. This policy aims to strengthen both commercial and defence capabilities. However, as representatives from an Indian space industry trade group pointed out, the pro-indigenization policy sends a confusing message to foreign investors that Indian firms are trying to attract. Ultimately, India still depends on foreign investment for many subsystems, components, and materials.

Table 2: Summary of Indian Space Sector Reforms (2019-Present)

Year enacted	Measure/Reform
2019	New Space India Limited (NSIL) established a new public sector undertaking company to steer the commercial exploitation of space products, services, and technologies by facilitating industry participation and technology transfers from ISRO to the commercial sector. *The establishment of NSIL has contributed to technology transfers from ISRO that have benefited firms involved in upstream activities in the space value chain.*
2020	The Indian National Space Promotion and Authorisation Centre (IN-SPACe) is a "single window nodal agency" to boost the commercialization of Indian space activities. IN-SPACe's mandate is to authorize space activities, promote industry clusters and incubation centres, and ensure equitable access to space infrastructure. *IN-SPACe's mandate as an industry regulatory and promoter impacts private firms participating in all segments of the space value chain.*
2022	The Department of Space announced India's National Geospatial Policy, liberalizing geospatial data acquisition, processing, and dissemination. The policy focuses on achieving Sustainable Development Goals (SDGs) and promoting India's self-reliance on geospatial data. It also invites the Indian private sector to participate in commercializing geospatial services. *The National Geospatial Policy encourages domestic geospatial entrepreneurship to meet its objectives. While this would stimulate all parts of the space value chain, it would particularly benefit firms involved in midstream and downstream geospatial activities.*
2023	The Indian Space Policy 2023 outlines key stakeholders' roles in space activities. The scope of ISRO, DoS, In-SPACe, and NSIL reflected in this policy are as follows: ISRO is set to transition from contributing to space technology manufacturing to focusing on R&D in advanced technology that meets national objectives, including long-term projects like Chandrayaan and Gaganyaan. The policy tasks ISRO with sharing technology and best practices with other government and non-government companies. The Department of Space is now the nodal department for implementing space technologies and coordinating international cooperation and global space governance and programs, in consultation with the Ministry of External Affairs. DoS must also provide overall policy guidelines to regulating entities and create a dispute settlement mechanism for space activities.

	IN-SPACe is designated as the private space industry's sole regulator, and must create a stable regulatory framework to ensure a level playing field for non-governmental entities. NSIL will continue facilitating the commercialization of space technologies and platforms created through public expenditure. *The Indian Space Policy 2023 clearly states that private entities may engage in a range of space activities at all levels of the space value chain, from launching and operating space assets to operating ground services to establishing space situational awareness (SSA) assets.*
2024	India has recently finalized a new foreign direct investment (FDI) policy for the space sector, which liberalizes rules for foreign ownership to help attract foreign investment in areas including satellite manufacturing, ground segment, launch vehicles, subsystems, and more (Jones 2023). *India's novel space sector FDI rules allow for 100% foreign investments in satellite manufacturing without government approval needed, and eased investment policies on launch vehicles.*

Since 2019, the Modi government has enhanced the private sector's role in India's space economy, and repositioned ISRO as a key facilitator. New entities like NSIL and IN-SPACe support private sector growth. ISRO and IN-SPACe have successfully engaged with startups, exemplified by Skyroot Aerospace's launch of India's first privately developed rocket, Vikram-S, in 2022, with substantial support from both agencies (Rajagopalan 2022).

The release of the Indian Space Policy 2023, which outlines the Indian government's vision for building up its space capacity through leveraging the private sector, has done even more to prioritize private participation in space activities, particularly those with civilian applications. Most significantly, the policy envisions the reorientation of ISRO and the Department of Space's mandates from manufacturing and production of space technology to managing domestic and international space policy, technology sharing, and guiding India's overall strategic vision in space.

Representatives from Indian think tanks and space industry groups we interviewed acknowledged that the Indian Space Policy from 2023 is a good starting point for encouraging private sector-led growth and innovation, particularly among start-ups. However, they also emphasized that the Indian government has yet to release subsequent guidance on space defence asset prioritization, or pass concrete regulations through a comprehensive Space Bill, which would provide further clarity to private firms and investors.

ISRO's policy change (to open its technology and labs to startups) has fostered innovation and strengthened linkages between the public and private sectors. As we heard from various startup founders, IN-SPACe has also been a valuable resource in helping newer firms navigate logistical and

bureaucratic challenges. While industry advocates and private space firms we spoke with acknowledge that Indian space sector reforms are still nascent, and it may take at least 5 to 10 years to see tangible impacts, they underscore the importance of the Indian government driving this momentum through concrete measures, like a comprehensive Space Activities Bill. They also argued that the PMO – and not just ISRO – has a crucial role to play in addressing remaining issues with adequate funding and urgency.

India's strategic challenges along its borders have demanded increased focus on intelligence, surveillance, and reconnaissance (ISR) capabilities that rely on space-based assets. Moreover, a renewed global focus on space militarization has led India to enhance its space-based defence capabilities. In response to the US Space Force's establishment in 2019, India directed its existing Defence Research and Development Organization (DRDO) to support R&D in military space technology and established the Defense Space Agency (DSA) to manage military space assets, and directed the existing (V 2021).

India's aims to pursue defence indigenization and self-reliance in strategic domains, including outer space, have intensified due to major global conflicts. The recent Russia-Ukraine and Israel-Gaza wars have strained the military resources of countries like the United States, Russia, and Israel, from whom India procures military equipment. This situation has underscored India's vulnerability due to its dependence on foreign Original Equipment Manufacturers (OEMs). Consequently, these external pressures have intensified India's drive toward defence indigenization and self-reliance, particularly in strategic sectors, including outer space.

While defence is an area where India's private space sector can add value, India has yet to connect these demands with its domestic space suppliers, especially younger startups. Commodore JS Shergill (Retd.), a former Indian naval officer, explained this point in a 2024 op-ed for SIA India, arguing that the confidential nature of India's military space priorities domain prevents space industry newcomers from building technology with innovative space defence applications.

The Indian Ministry of Defence's Innovations for Defence Excellence (IDEX) Space Challenge scheme provides funding for startups to prototype and build products for the Indian military. Prime Minister Modi announced 75 IDEX Space Challenge areas at DefExpo 2022 in Gujarat, covering topics from AI/ML applications of geospatial imagery to anti-spoofing circuits for PNT services. This initiative aims to encourage innovative solutions to meet specific space asset needs. However, there is a need for clearer space defence priorities in India to enable startups to better innovate for defence applications, as compared to startups in the United States.

The Private Sector's Growing Role in the Indian Space Industry

The Indian government's recent efforts to end its monopoly on the country's space program have significantly boosted the private sector in the past few years. While ISRO still possesses the funding and political backing to undertake larger, riskier projects like human spaceflight and planetary

defence, the private sector has access to technology and capital to pursue projects that will scale up India's space industry.

Startups have been essential to the growth of India's private space sector, attracting significant private investments despite global market slowdowns from 2022 onward. However, overall venture funding remains less readily available in India compared to other major space-faring nations, especially for capital-intensive upstream space innovations. Consequently, many Indian startups are setting up parent companies in the United States, Europe, or Singapore. to take advantage of better opportunities for private and public seed funding for space startups (Dhingra 2022).

Besides private capital, the Indian government is another significant funding resource for domestic space startups, committing $112 million to firms in 2022 alone (The Hindu Bureau 2022). However, Indian government funding and procurement procedures are still insufficient, as startups often lack funding to bridge the gap between building a prototype, demonstrating a proof of concept, and scaling up operations.

A space startup we interviewed elaborated on the apparent mismatch between government procurement contract terms and the startup product development cycle. One of the founders remarked, "*Right now, the biggest concern for space and defence startups is [to build and scale] for a longer time horizon, and without a contract in place, they have no guarantee they can continue for very long, as they might not exist in three years.* "Another aerial and spatial defence startup founder we talked to echoed this sentiment, and added that venture capitalists are also less eager to give money to startups if government procurement contracts are not certain, creating a vicious cycle of limited long-term funding sources for startups.

Easing procurement contract bid requirements for startups can also help stimulate growth in India's private space sector. ISRO and DRDO are primary target customers for Indian space startups, but their contract terms have strict requirements that favour larger, more established firms. For example, current procurement policies stipulate that firms must have over 500 employees, demonstrate a prior track record and profitability, and provide security deposits and performance bank guarantees. These policies make it virtually impossible for startups to compete for government contract bids outside of IDEX Challenge Schemes, which inhibits overall growth and innovation from India's space startup sector.

As a result, the Indian space sector risks long-term brain drain, as many Indian space startups that have struggled to find a domestic market are already opting to find customers abroad (Dhingra 2022). Startups struggling to find a market in India often seek growth abroad. New Indian space companies, like Bangalore-based Pixxel, set up offices in the US to access capital and reach foreign markets. This strategy paid off for Pixxel, which raised $36 million in a Series B round led by Google in June 2023. Pixxel is also one of six commercial providers that signed agreements with the United States National Reconnaissance Office (NRO) in March under the agency's Strategic Commercial Enhancements program for hyperspectral imagery.

Pixxel's ability to secure the NRO agreement, which allows the agency to assess the company's technical and business plans and later procure hyperspectral data for demonstrations, can be largely attributed to its physical presence in the US market (The Economic Times 2023b). Pixxel's success abroad reflects the current opportunity gap within India's space market and is a testament to the opportunities that access to and collaboration within the US space sector.

2.3 Aligning US and Indian Space Value Chains

US-India collaboration is not just beneficial for Indian space companies. As the Indian space sector continues to evolve, the United States could gain from India's upward trajectory. India's present strengths are still modest but show a lot of promise.

- India boasts an 8.1% and 13.% compound annual growth rate (CAGR) in satellite manufacturing and launch services, respectively.
- On the whole, ISRO has proven its reliability in launch services, with 381 successful satellite launches for 34 countries, while utilizing a cost-effective approach that has been recognized by its international partners (Indian Aerospace and Defence Bulletin 2023).
- India also shows strength in satellite and ground segment services, representing 4.2% and 6.9% CAGR, respectively (Bhatt, Kant, and Sharma 2023).

Meanwhile, India's private space sector is growing exponentially, with space startups flooding the sector and contributing to segments across the space value chain. In 2021, India registered 368 space-focused companies— the fifth-largest concentration of space companies globally (Bhatt, Kant, and Sharma 2023). While still growing, India's private space sector is showing strengths across the space value chain. Startups in the upstream segment focus on satellite and rocket manufacturing, rocket fuel, and propulsion systems, while downstream startups develop data analysis and innovative end-user applications.

India's private space sector shows promising growth and potential. In a speech made to the 74th International Astronautical Congress held in fall 2023, IN-SPACe Chairman Pawan Goenka underscored India's strengths in small satellite manufacturing, and identified small launch vehicles and low earth orbit (LEO) constellation services as key growth areas (Jones 2023). Space industry stakeholders we spoke with also noted India's software capabilities for downstream space data services, leveraging the country's strong software talent.

Below, we assess the Indian space sector's strengths, which could generate investment and collaboration from the US government and US-based space firms across space value chain segments.

Table 3: Areas Where the Indian Space Value Chain Can Benefit the United States

	Innovation	Cost	Supply Chain Diversification	Market Access
Upstream	Small satellite constellation systems; Satellite design; Space-based sensors	Satellites and space hardware components; Launch services	Satellite subsystem components; Launch services	Supply of launch vehicles to Indian / Asian markets
Midstream		Small payload launch operations and maintenance	Ground station support services; Satellite communication services	Ground station support services
Downstream	SSA data fusion and processing; Higher-value geospatial imaging data	Software design; Space-based data processing, analysis, and distribution	Space-based data processing and analysis	Cloud computing capacity; Telecom services; Data value-added services

Innovation: India's innovation is evident in technological advances by space startups in the upstream and downstream segments, despite cost and capital constraints. Notable advancements include LIDAR and hyperspectral sensors, which can benefit US firms, and innovations in geospatial imaging and SSA data fusion in the downstream segment. In Bangalore, we spoke with the leadership at SSA and high-resolution geospatial imaging startups that are attracting attention from US-based firms like Google and SpaceX and the United States Space Force. We anticipate that future growth in India's innovative capacity in space, driven by startups, can produce technology that will be a value-add to the US space market.

Cost: India's space program is well known for its cost-efficiency in upstream launch services and satellite production. ISRO's low-cost approach is exemplified by its Polar Satellite Launch Vehicles (PSLVs), which cost about $25 million per launch, or $6579 per kilogram, to low Earth orbit. By comparison, NASA's SLS rocket costs $28,572 per kilogram (The Economic Times 2023c).

ISRO's frugal mindset mirrors the approach of many commercial space firms that are driving down costs of space assets. This includes a willingness to take calculated risks, optimize resources, and indigenize critical components. Indian space startups, many of which are run or mentored by former

ISRO employees, also embody this mindset and manage to build hardware and software at considerably low costs.

According to a venture capital investor based in Bangalore that we spoke with, Indian startups have the potential to produce high-quality hardware that could lower satellite production costs and disrupt the space market. However, he also mentioned that inefficiencies in India's space sector could hinder firms from maintaining cost advantages in the global space market. A space policy researcher from a Bangalore-based think tank echoed this sentiment, stating that India's cost advantages in the space industry may not last long enough to outperform firms in more efficient markets.

Despite this, the experts agree that India's labour force will remain cost-competitive due to its large, highly skilled, and relatively low-cost workforce, which can contribute to various segments of the space value chain. The same investor we spoke with also pointed out that India's labour cost advantages in the space sector are offset by the industry's less-developed ecosystem and regulatory burdens, making it less efficient. However, if the Indian government works to address these challenges, cost-efficient labour could be an advantage for India in the future.

Supplier diversity: The US government's primary supplier base is largely undiversified, relying heavily on the same set of US-based companies to support high-risk and high-expenditure space projects. For example, a handful of traditional defence companies and newer space companies carry out projects for NASA's human space flight and cargo transport programs.[1] While limited demand has driven the lack of supplier diversity for the US space program, the expected increase in future space activities in the decades to come will increase demand for space assets and launch capabilities, which will constrain existing suppliers.

Additionally, the United States' geoeconomic and geostrategic concerns toward countries like Russia and China contribute to a broader reorganization of global supply chains in critical technology sectors like space. These factors make India a prime destination for alternative sourcing in launch services, satellite and subsystem component manufacturing, and downstream services. As India begins to ramp up space-focused manufacturing and services across all levels of the space value chain, the US government and US firms can look to India to diversify their supply chains to hedge against market and geopolitical risks.

Market access: As India's space industry matures, US space and defence companies will likely want to gain more reliable access to Indian commercial and defence space markets. Given that India may rival China as a regional space power in the future, US firms will likely want to leverage their presence in India to access additional markets in the Indo-Pacific region. The United States can attain strategic and commercial advantages through having market access in India, particularly in areas specific to SSA and geospatial imaging.

One SSA startup leader we spoke with in Bangalore pointed out that though data sensors required for SSA and earth observation are all positioned all over the Western hemisphere; they are sparsely located between the Middle East and China. US firms can establish a presence or strike tie-ups with Indian firms to help build out data sensors that can serve the United States' civic and defence priorities.

An Indian defence startup founder we spoke with in Bangalore pointed out that India's vast geography and diverse terrain make it an ideal test environment for geospatial imaging and weather monitoring. US space firms can utilize India as a viable market to test and develop space-based products and services. Additionally, US companies can take advantage of Prime Minister Modi's Make in India initiative to launch partnerships with Indian companies and attract Indian talent, which may help them score political points.

For US firms to successfully penetrate the Indian market, partnerships must align with the interests of both Indian and US companies. Indian companies are seeking technology transfer from US firms, which possess a comparative advantage in advanced space technology. However, US firms are reluctant to share technology due to potential competition, despite the allure of capitalizing on lower-cost Indian software talent. Collaboration may face obstacles unless US firms commit to significant technology transfer, thereby enabling more productive partnerships.

Additionally, while the opportunities for bilateral collaboration are compelling incentives to bring the US and Indian private space sectors closer, prevailing regulatory and policy challenges could impede the relationship's progression. In the following section, we will delineate the barriers to collaboration between the US and Indian private space sectors and identify the contributing parties.

Part III: Barriers to US-India Collaboration in Space

Despite powerful market incentives and high-level political support behind US-India space collaboration and ecosystem integration, many institutional, economic, and bureaucratic barriers will blunt progress if they remain unaddressed. Interviewees highlighted the most significant barriers and how they impact the bilateral space relationship.

3.1 Barriers Within the Bilateral Relationship

<u>Geopolitical Uncertainty:</u>

Growing geopolitical alignment boosts collaboration, but uncertainties about the US-India relationship and broader geopolitics hinder it. Indian space companies rely heavily on US components, but American priorities favour domestic and defense customers. Geopolitical events, like Russia's invasion of Ukraine, have caused costly supply chain delays for Indian firms. Such vulnerabilities could affect India during future geopolitical crises, such as a hypothetical Taiwan Strait

conflict. Despite significant high-level momentum behind the US-India relationship, ambivalence and anxiety over the closeness of the relationship persist both within the private sector and at lower levels of each government's bureaucracy.

As a senior figure at a US aerospace trade association described, US industry views India's democratic backsliding and treatment of ethnic and religious minorities, as documented in the State Department's annual human rights report, with caution (U.S. Department of State 2023a). He explained that US industry is concerned that these developments along with actions of the Indian government, such as its plot to assassinate an American citizen in New York City, will harm the overall bilateral relationship and thus hurt government support business between the countries (McKinley, Barnes, Austen 2023).

Western diplomats and many in the Indian space industry pointed to US abandonment of India after the 1998 nuclear tests and contemporary tensions, including over Russia and Pakistan, as undermining Indian confidence that the US will continue to be a reliable partner. This, in turn makes the Indian government and firms reluctant to become what they perceive as too reliant on the US and contributes to the Indian goals of indigenization and strategic autonomy.

Trade Barriers:

Indian space companies import 95% of their components, with a large percentage coming from the US (Tejaswi 2023). One larger, well-established space company told us that imported components are its single largest cost. Tariffs raise those costs for Indian companies substantially. Multiple start-ups described the cost burden of tariffs, with one telling us that tariffs raised the cost of American components by 42%, and another estimating the cost increase at over 30%. All companies we spoke with mentioned that tariffs significantly raised expenses.

Companies also noted that customs and import approval permits can be costly, given the delays that they cause. In addition to the general effects of duties on Indian business, significant tariffs make American suppliers less appealing to Indian companies. Especially in comparison to some third countries like South Korea, which have FTAs with India or might negotiate them in the future, high tariffs on American components could undermine the supply chain linkages between India and the US that support ecosystem integration (Hindustan Times 2024).

Beyond tariffs, non-duty trade barriers such as differing technological standards also impact the relationship. Different standards mean that interoperability decreases and that systems cannot be built together as easily by American and Indian companies. For instance, American companies use NATO-defined standards while Indian companies do not.

3.2 Barriers on the Indian Side

India's Regulatory Framework for Space:

The continuing uncertainty in the Indian regulatory environment holds the sector back, including deterring foreign investment. Since the space sector was only opened to private companies five years ago, Indian space policy is not fully settled. Changing or not-fully-defined mandates for ISRO, IN-SPACe, NSIL, and the private sector make it difficult for foreign companies to know what parts of the ecosystem they will be allowed to play, which discourages investment (Rajagopalan 2023).

Passing a comprehensive Space Activities Bill has proved difficult; an initial draft was released in 2017, however, the legislation has still not been passed into law. Though the Indian Space Policy (released in April 2023) brought much-needed clarity, and is expected to serve as the basis for an eventual Space Activities Bill, true policy certainty will not come until legislation is passed. For instance, the new policy does not fully specify IN-SPACe's powers and responsibilities (Singh 2023).

A think tank we spoke to emphasized that the agency functions as a regulator and promoter, while the larger space sector still lacks a fully independent regulator. Furthermore, commercial access to particular technologies continues to change. One start-up explained that this year, 50-centimeter resolution satellite imagery was only approved for the private sector.

Further, American companies working with the Indian government face complications due to misalignment between central and state governments. Promising initiatives can falter if state governments do not align with central policies. For example, one trade association we spoke with cited Tamil Nadu as a case of Centre-State policy misalignment affecting business. Centre-State agitations across a range of domestic political issues have impacted Tamil Nadu's access to Union funds and necessary permit approvals to support capex investments, especially in new construction (Moorthy 2013, The New Indian Express 2024). Once hailed as a major centre for automotive manufacturing sector in Asia, these governance issues dampened Tamil Nadu's investment climate in the 2010s, triggering headwinds for future would-be investors (Isaac 2018). The issue of Centre-State misalignment is particularly challenging for American firms when it stems from Indian domestic party politics, which is both delicate and difficult for American firms to fully understand.

Funding and Financing for Indian Firms:

The Indian government recently announced a new FDI policy for the space sector, outlining rules for foreign investment in India's private space industry. This policy aims to ease foreign investors' concerns. Whether it will lead to increased investment remains to be seen. When we spoke to a small start-up working with the Indian government to manufacture drones, the firm's CEO said there was "*anxiety among foreign companies to invest in India.*"

The lack of a codified set of rules for foreign stakeholders, combined with the nascent nature of the Indian space private sector ecosystem has led investors to shy away from pursuing India as a stable place to invest capital. Even if foreign investors are interested, they are nervous to invest in a place with no demonstrable historical credibility for return on investments.

There is significant innovation in India's space sector, making it attractive for U.S. companies to acquire Indian firms and their IP. However, India's venture capital culture is conservative, often undervaluing start-ups for their IP and lacking space sector expertise. This creates an opportunity for U.S. companies to invest with little competition. Nonetheless, Indian firms are sometimes hesitant to be acquired, and the lack of a finalized FDI policy complicates joint ventures, limiting access to India's technological innovations.

Government Procurement:

The Indian government is a major customer for space-related products, potentially appealing to American companies. However, barriers exist, such as ISRO's established relationships with long-term suppliers familiar with its needs. This makes ISRO less likely to switch to potentially more expensive American suppliers, especially as these companies already have access to the larger U.S. market.

Several factors hinder U.S. companies' participation in Indian defence procurement. The Indian military's lack of clear priorities complicates navigation for both Indian and American companies. The bureaucratic and hierarchical nature of the Indian government makes it challenging for U.S. companies to identify key contacts. Furthermore, the Indian government prioritizes local industry, often awarding contracts to Indian firms to support this goal.

3.3 Barriers on the U.S. Side

US Business' Incomplete Understanding of the Indian Market:

Although American companies recognize the potential in the size of the Indian market, lack of cultural familiarity and inexperience in the Indian market can both lead to poor investment decisions and a lack of investment altogether.

An Indian space industry trade group stressed that for American companies to gain market share in India, they need to better understand India's commercial use cases for space technology and tailor their products accordingly. For instance, there is growing demand for spatial imaging in the agriculture sector and American companies neither understand Indian agriculture nor appreciate the importance of agriculture in the larger market. Similarly, senior leadership at a major Indian company told us that US companies need to be more willing to make long-term investments in India and take the time to understand India's market even if that is not initially profitable. Finally, an Indian startup conveyed that US space companies need to be willing to be the first to invest in India instead of waiting for other Western companies to move first.

Export Controls, Including ITAR

Among the various barriers we identified through our interviews, the International Traffic in Arms Regulations (ITAR) was consistently mentioned by all our interviewees. ITAR is a set of rules

regulated by the U.S. Department of State that controls the import and export of defence-related goods and services, including those relevant to the space sector. ITAR covers a wide range of products, such as weapons, military vehicles, spacecraft, software, and associated technical data. Its main goal is to prevent sensitive military and space technologies from falling into the wrong hands. This presents a barrier to Indian companies, and also affects close American allies like the UK and Australia, due to its focus on safeguarding sensitive American technologies.

Through our interviews, we understood that there were two different ways ITAR poses a barrier for small and large businesses:

1. **Small Businesses, and the high costs associated with filing ITAR papers**

   There are substantial expenses involved in filing ITAR paperwork, which can be prohibitive for smaller entities like start-ups. ITAR registrants must be based in the United States, and Indian companies must be incorporated within an American company or be independently registered in the United States to start the ITAR process. Following the paperwork, companies will embark on a complex and time-consuming ITAR process. Startups have emphasized that it can sometimes be unclear what is truly subject to ITAR regulations.[2]

2. **Large Businesses, inability to get technology transferred**

   In our interviews with larger firms, instead of expressing concerns about costs, we encountered complaints about delays in approvals and licensing for specific technologies. In an interview with a large Indian infrastructure conglomerate currently partnered with an American defence company, we heard that "resistance on the part of the United States to tech transfer is a major roadblock." Even after finalizing a contract with an American defence company, ITAR regulations prevented the Indian conglomerate from initiating their project. Notably, most space collaborations do not require ITAR-controlled items, indicating that criticisms of ITAR may sometimes arise without direct relevance to operational requirements.

Despite the complaints voiced about ITAR by interviewees, US government officials we spoke to made it clear that the United States has made considerable efforts to assist Indian firms with filing ITAR exemptions. The government aims to expedite ITAR exemption approvals within a 60-day timeframe and has organized workshops for Indian startups to navigate ITAR and export control procedures. However, feedback from numerous Indian startups indicates a need for enhanced expertise within the US government to effectively address specific and technical questions about ITAR.

Visas

The US visa system continues to stymie travel to the US that facilitates commercial collaboration. Our research revealed that many smaller Indian startups had issues getting visas to the United States, especially without existing or former collaboration with an American company.

A member of an Indian space trade association said "[People working at] startups often can't get visas. People who already [happen to have] long-term visas can renew quickly. But startups are small and new, so they find it very tough to get an American visa." They described prohibitive wait times and trips to the US that could never take place. Without easier access to visas, the type of exchange between entrepreneurs on which ecosystem integration depends will be impeded.

Part IV: Policy Recommendations for the US and Indian Governments

In the preceding sections, we mapped the evolution of the US and Indian space sectors, the trajectory of the US-India space relationship, and the barriers and incentives that shape it. In this section, we recommend policies for key stakeholders in the US and India to strengthen the bilateral space relationship even further. These recommendations consist of joint initiatives and steps that each government can take individually to boost their private sectors, facilitate private sector integration, and strengthen bilateral technology cooperation.

4.1 Recommendations for The United States Government

<u>Simplify ITAR and Enhance Export Control Mechanisms for Innovation:</u>

While navigating the complex ITAR process is challenging for close allies and new partners, there's no avoiding it. However, to bolster the US-India space relationship, the United States must review and simplify ITAR concerning space situational awareness and software capabilities. India's strength lies in its downstream capabilities, yet ITAR restrictions have hindered access to essential software for startups. Streamlining ITAR regulations tailored to India's downstream sector would incentivize prioritization of this sector, thus fostering US-India collaboration (U.S. Department of Commerce and Federal Aviation Administration 2017).[3]

In addition to reviewing software-specific ITAR regulations, the US Department of State should continue its ongoing effort to educate Indian startups about navigating ITAR (U.S. Department of State 2023b). Many startups have found these roadshows to be useful. However, startups have also cited the lack of clarity over which technology is subject to ITAR restrictions, and/or lack of capacity within their often-resource-constrained teams to attend such sessions. As such, we recommend employing people with the right ITAR technical knowledge to manage these roadshows to answer specific questions targeting a wide range of space startups across India.

Indian companies must realistically acknowledge that the United States is unlikely to swiftly or easily revise these procedures. ITAR is a barrier for even the closest American allies like Australia and the UK. A healthy dose of realism over ITAR is needed from the Indian side when navigating this complex process. Streamlining ITAR will be a gradual, iterative process.

Promote Better Understanding of the Indian Market and Facilitate Exchanges:

The Indian market differs significantly from the US, characterized by low margins, high volumes, and a strong focus on agriculture-related technology. Cultural differences, diverse conditions, and varying consumer purchasing power shape product success. Without understanding these factors, American companies may struggle to succeed and be less appealing as partners for Indian firms. The Department of Commerce should facilitate connections between US companies and potential Indian partners, and encourage US companies to invest the necessary time and resources to fully understand the nuances of the Indian market.

In parallel, the US State Department should create joint workshops, symposia, and internships for emerging space industry leaders from both countries.[4] These would increase understanding of shared challenges and opportunities and foster a collaborative ecosystem conducive to space technology innovation. To strengthen government-to-government and private-sector relationships, investments in India-focused technology programs (like the one that yielded this paper) and Hindi language programs will create a generation of private and public sector leaders with a much better understanding of India. In addition to creating new initiatives and further facilitating exchange, the State Department should continue to make it easier for Indians to obtain visas to the US by addressing long wait times.

4.2 Recommendations for the Indian Government

Support for Foreign Investment to Complement the New FDI Policy:

India's newly finalized FDI policies for the space sector provide needed certainty and permit greater foreign investment. FDI can now account for 100% of investment in satellite components, systems, or sub-systems, and up to 74% and 49% of investment in building satellites and launch vehicles, respectively, without special approval (Reuters 2024). India should automate FDI approvals and create a new Space Investment Facilitation Unit to accompany these new rules.

India should streamline approval processes for space-related investments to attract foreign investors. By implementing automated approval procedures, India can eliminate bureaucratic delays that have historically slowed down projects and discouraged potential investors. This will not only improve the investment climate and boost investor confidence, but also support both new and existing players in the space industry.

Creating a specialized Space Investment Facilitation Unit within the Indian government can simplify the investment process for foreign entities interested in entering the Indian space sector. Like how IN-SPACe facilitates domestic investment and procurement, unit could serve as a central point of contact for identifying and supporting foreign investment opportunities, providing guidance and support tailored to the needs of US firms. Along with fast-track FDI approval mechanisms, India can ensure that space projects proceed without unnecessary delays, ultimately contributing to the growth and competitiveness of the Indian space industry on a global scale.

Expedite the Passage of Comprehensive Space Legislation:

India should prioritize passing a comprehensive Space Activities Bill. The regulatory certainty that the legislation would provide is an essential tool to bolster India's position in the global space economy, attract more foreign investment, and support the overall growth of the space industry. Though the space industry pushed to finalize and pass the bill following the release of the Indian Space Policy 2023, another year has passed without parliament passing the Space Activities Bill.

Legislation would be key to creating a legal framework supporting public and private sector engagement in the space industry. Based on our conversations with industry stakeholders, this bill should specifically address the following issues:

- *Legal Protection and Incentives for Private Investment:* The Space Activities Bill should include provisions that protect and encourage private investments. This may involve legal safeguards against sudden policy changes, guarantees of intellectual property rights, and incentives such as tax breaks or grants for research and development.
- *Framework for Public-Private Partnerships (PPPs):* The bill should outline a framework for PPPs that allows private companies to have a more significant stake in space missions, and set clear rules governing public-private collaboration. Additionally, the legislation should facilitate partnerships, leveraging private sector innovation and government resources.
- *Open and Transparent Bidding Process:* The Space Activities Bill should mandate open and competitive bidding processes for government contracts related to space activities, providing fair access to opportunities for startups and private companies, and fostering a more competitive space industry in India.

The upcoming bill should also build on the Indian Space Policy 2023, by formalizing existing effective policies and addressing unresolved issues. Resolving IN-SPACe's dual roles and potential conflict of interest is imperative to ensure a fair competitive environment for the sustained growth of the space industry. Clarifying the roles of newer space institutions like INSPACe and NSIL would contribute to creating a reliable investment environment and fostering innovation.

Stimulate Further Growth in Targeted Sectors of the Indian Space Industry:

One of the most meaningful things India can do to boost space ecosystem integration is to support the growth in capabilities of its private sector which in turn provides U.S. companies with a wider range of potential India partners. To accomplish this, the Indian government should:

- *Define* clear space defence procurement priorities to provide guidance for potential investors, both domestic and foreign.
- *Extend* tax exemptions and review tariffs for private-sector rocket vehicles, satellites, and ground equipment to reduce costs and facilitate integration in the US-India space ecosystem.
- *Establish* a tailored Product-Linked Incentive (PLI) scheme for space manufacturing to accelerate industry growth, fill funding gaps, and attract private and foreign investment.

Build Trust and Assurance by Safeguarding Critical Government Processes:

The Indian government should enhance its security infrastructure to foster American trust when handling sensitive information. Given the critical nature of dual-use technology in the US-India space relationship, strong confidence is vital for closer collaboration. Investments in secure physical and cyber infrastructure will boost American confidence. Expanding bilateral cybersecurity cooperation, such as through the US-India Cyber Security Initiative, aligns with both nations' concerns about anti-satellite cyber threats. These measures could lead the US to ease ITAR and export controls, and aid with the advancement of a Reciprocal Defense Procurement (RDP) agreement with India, which would provide interoperability and market access (The Economic Times 2023d).[5]

4.3 Joint Recommendations for The United States and Indian Governments

Continue Alignment on International Space Norms and Regulation:

The Artemis Accords were momentous in aligning the US and India on space regulation. As global norms evolve, the two countries should continue coordinating internationally to ensure a favourable environment for their space sectors and sustain political momentum. Shared best practices in governance, regulation, and sustainability will set a precedent for responsible space exploration.

Establish "INDUS-X for Space":

The US and Indian governments should develop a comprehensive framework to enhance space sector integration and innovation, using INDUS-X as a model. This framework should include joint challenge grants, accelerators, university-private company programs, and mentor-protege initiatives. Additionally, they should establish a supportive venture funding ecosystem through public-private partnerships, R&D grants, and private investment incentives. The CSJWG's new Commercial Working Group could negotiate this framework, led by the US Department of Commerce and India's Department of Space.

Create a Common Investment Framework:

The U.S. and Indian governments should establish a specialized framework for investment in the space sector. This framework would simplify investments and provide a legal structure for joint ventures and partnerships between U.S. and Indian space entities, as well as establish market access rules to facilitate smoother space-related trade (United States Trade Representative 2024).[6]

By incentivizing joint ventures and easing regulatory restrictions, both countries can foster the development of cutting-edge technologies with shared intellectual property rights. Furthermore, amid the negotiations for a U.S.-India defence procurement agreement, it is essential to ensure the inclusion of the space sector. This agreement has the potential to enhance supply chain integration and collaborations, opening up new possibilities in the space sector once it is finalized.

Provide Necessary Confidence for Overseas Incorporation:

Given the importance of government contracts to each country's space ecosystem, Indian policy analysts suggested that companies are hesitant to do anything they might perceive as jeopardizing their ability to obtain government contracts. Both countries' major government purchasers should assure that creating subsidiaries in the other country will not harm their companies' ability to obtain contracts. Providing this confidence will boost collaboration by increasing the number of companies with a presence in both countries and making it easier for Indian companies with US subsidiaries to access technology subject to US export controls.

Part V. Conclusion

With private sector growth, political support, and frameworks like iCET, the US-India space relationship is set to integrate and enhance both countries' private sectors. For India, this collaboration offers opportunities to accelerate its space sector through technology transfer, FDI, and market access. India could specifically focus on developing advanced, low-cost launch services, satellite manufacturing, and leveraging its strengths in software and downstream services. Emphasizing India's comparative advantages and the US's expertise in propulsion and deep-space exploration can foster innovation and expand markets for both nations.

Successfully addressing the challenges holding back collaboration which this report details will ultimately determine the relationship's trajectory. Both countries should act deliberately and be willing to devote the necessary political capital to the policies that support space sector ties. Together, the governments should create a new, comprehensive framework to support private sector integration with institutions like an INDUS-X for Space and support for joint ventures.

Each government should address the bureaucratic hurdles embedded in their systems, like visas on the US side and tariffs on the Indian side. Following its newly released FDI policy that boosts foreign investment in the space sector, India should also take the full suite of necessary actions to ensure sustainable growth in its private sector over the long term as soon as possible. This suite includes creating a durable and fully impartial domestic regulatory regime by passing a Space Bill, clarifying space procurement priorities, and designing thoughtful tax and production schemes to support the young private sector in targeted subsectors.

India and the United States should understand the critical role of policy in achieving greater space sector integration. By intentionally addressing policy, regulatory, and bureaucratic hurdles, as well as other barriers, they can unlock the full potential of the US-India partnership.

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Notes

[1] These firms include Boeing, Northrop Grumman, SpaceX, Sierra Space, and the United Launch Alliance (Lockheed Martin and Boeing).

[2] Several Indian space startups we consulted expressed concerns about the prohibitive costs associated with ITAR compliance. Smaller startups, in particular, highlighted the high expenses of filing ITAR papers, which are burdensome given their limited funding, often needed for overhead costs. Larger, well-funded startups also pointed out the complexities of navigating the ITAR process, despite having the necessary resources. In both cases, ITAR posed significant challenges for both small and large startups and was a recurring topic of concern in our discussions with various companies and entities.

[3] As many Indian space startups teams shared with us, navigating ITAR restrictions and determining which components were covered under ITAR or Export Administration Regulations (EAR) proved to be onerous. The dual-use nature of many components – especially those required for downstream space activities – seemed to complicate export restrictions. While the US Department of Commerce's 2017 guide for navigating US export controls for the commercial space industry provides some clarity, similar documents should be reviewed and updated to assess whether some restrictions can be simplified or streamlined, given the global uptake in commercial space technology development.

[4] While our group spoke with US professors who are engaged in symposia and mentorship programs with Indian students and academics in space research and technology, we concluded that at this point, such exchanges are limited under to academic context under INDUS-X and direct US-India university partnerships. However, if the US Departments of State and Commerce were to facilitate exchanges tailored for US-India diplomatic and commercial engagement in space activities, high-level aims in the US-India space relationship are more likely to be met.

[5]In 2023, the US and India started discussions on brokering an RDP agreement, as well as a Security of Supply Arrangement (SOSA). An RDP agreement would allow Indian businesses to fulfill US Department of Defense procurement contracts, while allowing US businesses to fulfill Indian Ministry

of Defense procurement contracts. The SOSA would allow the US Department of Defense to request more rapid access to critical technology inputs and finished products from Indian companies.

[6] The United States currently employs a variety of tools to engage with key trade partners, such as Trade and Investment Framework Agreements (TIFAs), established with several trade partners worldwide. TIFA Councils typically convene annually, providing a forum for the United States and other countries to discuss mutual interests in various sectors. Although the United States and India currently do not have a TIFA, creating a similar framework to address space technology investment issues would be a first-of-its-kind initiative. It could help pioneer the development of forums between the US and key trade partners in addressing issues relevant to critical technology sectors.

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Decoding India's AI Governance Strategy and its Implications for the U.S.-India Bilateral Relationship

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Abstract

India is developing a unique approach to the governance of artificial intelligence (AI) and is staking out a leadership role in multilateral dialogues on responsible AI. This paper reviews India's available AI governance choices, as the country defines its regulatory model, and highlights their associated trade-offs. It also analyses these choices in light of the government's national priorities, as well as India's perceived advantages and weaknesses in various industries that might utilize AI systems. With this background, this paper examines how India's current approach to AI governance may impact the trajectory of U.S.-India technology cooperation.

Keywords: Artificial Intelligence, AI Governance, Emerging Technologies, Responsible Innovation, Technology Partnerships, Ethics, Regulation

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1. Introduction

Artificial Intelligence (AI) systems are groundbreaking technologies at the forefront of global innovation competition, presenting both incredible opportunities and significant risks to populations worldwide. In response, policymakers are navigating the complexities of this rapidly changing field, while attempting to strike a balance in AI governance, between harnessing the transformative benefits of AI, mitigating its potential harms, and prioritizing national interests in AI advancement. The year 2024 marks a crucial juncture for each country, as they decide which aspects of AI regulation to prioritize to achieve their national goals and shape this captivating technology. Among the countries actively structuring new policies and striving for a competitive edge in AI, India stands out as a noteworthy player with immense potential for success in this domain.

Our research delved into India's AI governance approach, assessing its alignment with global standards, including the U.S., given its significant role across technology sectors. Engaging with diverse stakeholders from both India and the U.S., including policymakers, civil society, academia, and industry experts, we aimed to uncover India's AI governance trajectory and its implications for international collaborations. We focused on India's current AI strategies, potential for regulatory harmonization, and its unique strengths in AI, to gauge its future regulatory directions and priorities. Our comparative analysis of global AI governance models explains India's possible role within the international AI supply chain, highlighting the challenges and opportunities for global partnerships.

First, we analysed how India's available AI governance choices and its current governmental priorities will shape its approach to AI. Until August 2023, India hesitated to enforce national AI regulations. However, a shift occurred last summer towards adopting measures to prevent user harm (Sasi 2023), likely influenced by emerging international efforts to regulate these systems across technologically-advanced states. Therefore, we present four pivotal decisions faced by the Indian government, each set to significantly impact India's AI development and policy trajectory.

Additionally, our analysis of recent AI initiatives and statements from Prime Minister Modi's Administration reveals a focus on enhancing India's global standing as a leader in emerging technologies, leveraging its workforce to integrate itself into emerging technology supply chains and utilize these technology innovations to further develop efficiencies across local industry sectors. This is highlighted by India's active role in international forums like the G20, and efforts to be a dominant force in AI governance to boost business, employment, and public services across sectors like finance, surveillance, healthcare, education, agriculture, and defence.

However, the alignment of India's AI ambitions with global standards remains uncertain, potentially affecting international collaborations; while some of India's AI initiatives and policies meet the ethical standards of groups like the Global Partnership on Artificial Intelligence (GPAI), its surveillance-based AI practices have received pushback from other member-countries, which could influence future partnerships. This intersection of India's AI priorities and regulatory approach with global strategies is a key focus of our research.

Second, we reviewed India's perceived comparative advantages and weaknesses in AI, given that these perceptions might shape how and where the government chooses to regulate the industry. India possesses AI strengths in data management, a burgeoning startup ecosystem, software expertise, and talent. However, challenges include limited high-level ML expertise, fragmented governance, and inadequate R&D funding. To capitalize on its advantages, India likely seeks a regulatory framework that avoids overregulation while fostering AI growth.

Finally, we conclude our report by presenting our policy analysis and recommendations, which are informed by our in-depth research within India. In this section, we discuss how India's emerging AI regulations align with its national goals and capitalize on its comparative advantages in the field. Finally, we explore how these insights might shape AI relationships with allied countries, especially through the U.S.-India bilateral relationship.

2. Indian Choices & Technology Priorities in Artificial Intelligence

2.1 India's Choices

While India aspires to lead the global AI landscape, Prime Minister Modi's government is confronting critical regulatory decisions to cultivate responsible innovation. However, like much of the world, India is still early in its AI governance journey. Given the unique innovation attributes India presents, determining the right regulatory approach requires a nuanced understanding of the country's unique economic, social, and cultural dynamics. Accordingly, we propose four pivotal choices that define effective AI regulation for all nations, which informed our analysis of India's forthcoming AI governance strategies:

A) Whether to establish a central AI governance framework, regulate sectorally in chosen sectors, or both.

In weighing whether to centralize AI governance, policymakers may take inspiration from the EU's approach to AI governance, as exemplified in the "AI Act." This framework is a comprehensive piece of legislation tailored to specific digital environments, while universally emphasizing risk assessments for AI across the EU. All AI systems under the "AI Act," are classified on a sliding scale of risk, from low to high, with legal stipulations for products based on their categorization ("Proposal for a Regulation of the European Parliament and of the Council: Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts" 2021).

In contrast, Canada's "Artificial Intelligence and Data Act (AIDA)," which serves as a companion document to current law, builds on existing Canadian consumer protections and human rights statutes to ensure high-impact systems meet the same expectations for safety and human rights ("The Artificial Intelligence and Data Act (AIDA)" 2022). India's approach remains unclear: a centralized framework could offer consistency, but might constrain rapid technological change, while sectoral

regulations could lead to fragmentation. Therefore, a key question we pursued in our stakeholder interviews was whether the Indian government will create a centralized AI governance framework.

B) Whether or not to defer to the private sector to adopt voluntary guidelines, restrict AI development, and establish ethical norms?

Countries like the United States rely on industry-led AI development with voluntary guidelines, prioritizing innovation over regulation. This strategy assumes that with its flexibility and innovation, private industry is ideally suited to spearhead AI development. By eliminating bureaucratic red tape, businesses are flexible to customize AI solutions to meet specific requirements, thereby stimulating economic growth and fostering social advancement. Yet critics warn that the absence of government-mandated regulations leaves space for risks like algorithmic bias. In this context, the Indian government may choose to govern the capacity of AI systems in risky contexts, such as using AI tools to decide whether individuals receive loans, immigration visas, or other sensitive circumstances.

Although there have been some government-led AI programs, such as the rollout of Facial Recognition Technologies (FRTs) in public surveillance, most AI applications in India are being introduced with little restriction by the private sector. The national government can let this private sector-driven innovation continue, or it can shift course and provide more explicit controls for these AI models in India. If India's authorities do not decide whether to establish regulations, private firms may continue to champion voluntary regulatory guidelines that define standards and norms in the AI realm.

Also, given its potential for broad-reaching societal impacts, the world's largest democracy must grapple with AI's potential to exacerbate marginalization and discrimination at an unprecedented scale. When creating AI ethical norms, these guidelines could relate to which contexts permit automation, what requirements should be incorporated into AI systems based on potential harm to the public, how technically robust an AI system should be before deployment, and how the impact of an AI system is assessed. If the government drafts these norms, it may do so by consulting knowledgeable AI experts, lawyers, and other informed parties, to assess how AI could negatively impact Indian society, and expend time creating a public report to curtail potential risks. Yet, relying on private firms to create these ethical norms means that AI benchmarks will, of course, be heavily influenced by private interests.

Yet, if the government does take the reins, it may look to several international models exemplifying ethical AI norms. For example, countries like the U.S. have provided national guidelines for the ethical development of AI in the "Blueprint for an AI Bill of Rights," while pursuing a moderately hands-off approach to regulation ("Blueprint for an AI Bill of Rights" 2022). Additionally, companies like OpenAI, Google, IBM, Microsoft, and other influential AI developers have codes of conduct and firm-specific ethical guidelines that set limitations for AI use. Similarly, the Indian government can

choose to provide these types of ethical AI guidelines rooted in the rule of law, allow organizations to take the lead in shaping norms, or leverage both mechanisms for AI governance.

So far, the Ministry of Electronics and Information Technology (MeitY) has published an industry-informed report that provides some ethical guidelines for automated government platforms, but these standards do not include universal ethical protocols. Accordingly, two key questions we used in our stakeholder interviews were: How may the Indian government rely on private-sector-driven decisions to restrict AI? What are the biggest risks associated with AI applications in India, and are government-led or private sector-led regulations best suited to mitigate those risks?

C) Whether non-Indian firms may access local data to train their models, and whether to restrict or limit foreign AI models in the Indian market.

In its mission to be a leading technology innovator, the Indian government faces several options regarding foundation AI models. One approach is to restrict the importation of machine learning (ML) models, thereby fostering local development.

Alternatively, the government could allow both domestic and international ML models to be used, with varying requirements for Indian-built AI components in specific sectors. For example, the government could mandate the utilization of Indian-designed machine learning models and local data in the healthcare sector, ensuring that automated decisions are tailored to Indian nationals. This initiative could mitigate the risk of inappropriate healthcare decisions resulting from biased AI models trained on foreign data, enhancing the quality of care for Indian citizens.

However, the need for Indian-made AI inputs may not be as pressing across all sectors, like finance, where models from other countries are often used. In these contexts, using AI models designed by other states and leveraging foreign data could minimize costs in implementing automation, without disproportionate risks to India's own population. The European Commission has highlighted how governments can navigate these trade-offs between costs and risks, by highlighting that AI systems that affect the administration of justice and crucial public services, like healthcare, should be classified as high-risk and have additional requirements, such as mandating models be trained by localized data ("Proposal for a Regulation of the European Parliament and of the Council: Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts" 2021).

Yet, the Takshashila Institution and other domestic civil-society groups in India emphasize the need for strategic autonomy across the entirety of India's AI stack, so that India's ML models reflect the perspectives and needs of its own population in decision-making (Reddy et al. 2024). At the initial time of writing for this paper, the Indian government had not provided guidance on where or how it would regulate the use of foreign ML models, which has since been updated by MeitY's March 2024 AI advisory (Soni 2024).

In the same vein, it was not entirely clear through existing legislation in what circumstances foreign companies may access Indians' personal data to train their models, but there was some indication in the 2023 Digital Personal Data Protection Act that cross-border data flows would be restricted with foreign firms (Vashista 2023). Nonetheless, the Modi administration's campaign for "Atmanirbhar Bharat Abhiyaan," or "self-reliant India," indicated that there is a strong interest among government officials to build India's own technology-driven systems, rather than permit foreign AI systems to dominate in India ("Atmanirbhar Bharat Abhiyaan: Self-Reliant India Campaign" 2023).

For these reasons, we incorporated two related questions in our interviews: Will the government permit foundation or application-specific AI systems to be used from other countries, with different requirements for Indian-built AI components in certain sectors? How may the government permit these types of systems to be used or require Indian-built AI components in specific sectors?

D) To what degree should the government invest in AI-related public infrastructure?

India's successful deployment of Digital Public Infrastructure (DPI) – including Aadhaar, Unified Payment Interfaces (UPI), and data management systems – has positioned the country as a leader in digital governance (*The Economist* 2023). Similar government control over AI infrastructure could ensure AI applications align with public interests, but necessitates significant financial resources. Conversely, partnering with the private sector can accelerate development and reduce costs, but may limit government influence over AI development. For example, the government could choose to control the development of cloud service providers and data collection mechanisms, or provide tax credits and other incentives to AI firms building this infrastructure.

The government's decisions on how involved it will be in developing AI infrastructure will significantly impact the scale of AI facilities available for startups and the computational capabilities of these organizations. Therefore, we asked local stakeholders about how the government may establish regulations or programs to accelerate government-led infrastructure construction and incentivize private AI capacity building, or look to the private sectors to pursue these programs. We also asked whether the Indian government will prioritize developing its own national AI infrastructure, including cloud services, compute facilities, semiconductor fabs, and data centres.

2.2 Overview of Research Project

During the six-month qualitative research study, beginning in August 2023, we met with government officials, academics, private sector representatives, AI developers, and non-profit thought leaders in the Washington, D.C. area. We also met virtually with representatives based in India, for their insights on AI topics pertinent to Indian stakeholders, and their perspectives on developing regulations. Additionally, on-the-ground research in New Delhi and Bangalore, where we interviewed individuals across the public and private sectors, provided firsthand insights into policy developments and potential U.S.-India collaborations. Additionally, we interviewed subject matter

experts on sector-specific AI policies and concerns in healthcare, economic development, finance, defence, surveillance, and education.

2.3 India's Technology Priorities

To understand India's AI priorities, we analysed government initiatives and India's broader political landscape. We found that the government is primarily focused on prestige, domestic security, and its developmental agenda – as outlined in the MeitY report "India AI 2023," which establishes and conceptualizes the Indian government's goals in developing and regulating AI.

2.3.1 Prestige

One of the broad ambitions of the current ruling party is their desire for India to rise as the *Vishwaguru* or 'world teacher,' which extends to AI (Sullivan de Estrada 2023). India has a favourable foundation for global leadership in this technology, thanks to its economic and geopolitical features. For one, it is the world's largest democracy and the world's most populous country, with millions of technologically skilled youths eager to contribute to its economic success.

While India's per capita GDP has risen by 245% in the last thirty years (largely driven by the technology sector), this growth has been inequitable, and parts of the country remain underdeveloped (Taneja and Zakaria 2023). Thus, to become the face of leading-edge technology, India must tackle the perception of being the "world's back office," by fostering the perception that India's institutions, its people, and its businesses are world-class and prestigious innovators.

2.3.2 Domestic Security

As a priority, the Modi government wishes to bolster domestic security through ML technology. To this end, the government has integrated AI into surveillance systems in India, which is a significant step toward improving real-time analysis and collecting actionable intelligence on domestic crime. This advancement is supporting proactive law enforcement and crisis management, and is aiding the government's efforts in improving local safety.

However, AI-based surveillance often reinforces biases, particularly related to caste, and can disproportionately target minority groups (Shah 2023). While some Indian nationals are more accepting of government surveillance compared to other democracies – evidenced by initial support for the DigiYatra facial recognition system at airports ("DigiYatra: A Contactless Air Travel Solution" 2024) – recent concerns over data misuse have led to a decline in its use since April 2024 (Bhargava 2024).

Internationally, India faces scrutiny for its data privacy practices, especially since the 1885 Telegraph Act and 2000 Information Technology Act offer inadequate protection against government data privacy violations (Boben and Patel 2023). Engaging in global dialogues and AI partnerships could help India develop a robust, standardized, surveillance framework that meets

international norms and addresses modern security challenges ("IndiaAI 2023: First Edition, By Expert Group" 2023).

However, the Indian government recently shirked this opportunity in August 2023 by passing the Digital Personal Data Protection Bill, which still exempts government agencies from privacy protections in this law (Boben and Patel 2023). Whether or not India will conform to the AI norms of democratic peers remains to be seen, but it is clear the government and its people prioritize surveillance over privacy as a social good – and look to AI applications to facilitate more sophisticated surveillance.

2.3.3 Developmental Priorities

India, despite its recent economic and technological progress, still faces significant developmental challenges, with 25% of India's population experiencing multidimensional poverty ("National Multidimensional Poverty Index: A Progress Review 2023," n.d.). Building on the success of the 'India Stack,' ("India Stack," n.d.) the government aims to become the "use-case capital for AI," focusing on agriculture, healthcare, sustainability, financial access, and education, rather than general AI advancement and development. This approach diverges from countries like the U.S. and China, who are vying for a competitive edge in advanced foundation models.

Agriculture

With approximately 70% of rural families in India primarily relying on agriculture for their livelihood, agriculture is a pivotal sector for AI integration ("FAO in India" 2024). Early-stage pilot projects, like the 'Saagu Baagu' program, which is part of the World Economic Forum's AI4AI initiative, successfully enhanced chili farming in India's Khammam district through AI-driven tools, doubling farmers' incomes and expanding to impact 500,000 farmers across ten districts.

Effective integration of AI tools for agricultural development may involve technology adjacent to the industry. Integrating farmers into the Indian credit system may make them eligible for formal business loans as opposed to informal, predatory lending ("AI for Agriculture: How Indian Farmers Are Harvesting Innovation" 2024). Additionally, initiatives like Bhashini, focused on language localization, are crucial for bridging the digital divide and ensuring that farmers can access vital agricultural information in their native tongues ("Bhashini" 2023). By combining technological advancements with supportive policies, India has the opportunity to create a sustainable, efficient, and inclusive agricultural ecosystem that empowers millions of rural citizens.

Healthcare

The Indian government seeks to bolster the availability of affordable healthcare, in tandem with the further integration of technology into the healthcare industry, to bridge the healthcare disparity between urban and rural populations (ET Bureau 2023). The IndiaAI 2023 Report explicitly sets an objective of enhancing healthcare accessibility across urban and rural areas by utilizing AI, and aims

to reduce the healthcare disparity, affirming quality healthcare as a right for its citizens. Central to this vision is the infrastructural development of AI-centric healthcare innovations ("IndiaAI 2023: First Edition, By Expert Group" 2023), which are expected to refine diagnostic precision, treatment regimes, and overall patient care (Maheshwari 2023). To date, AI has begun demonstrating its utility in the healthcare sector for mining medical records, crafting treatment schedules, and enabling early detection of critical illnesses ("Vevra Launches State-of-the-Art Hospital Pods to Fight COVID-19" 2020).

Sustainability and Climate Change

The India AI 2023 Report elaborates on the Indian government's ambition to harness AI for economic development while concurrently addressing climate challenges. For example, this report specifically emphasizes "*inclusive post-pandemic recovery and multilateral cooperation, focusing on labour market challenges, health infrastructure, climate finance, and debt governance* [...]." (Bhowmick 2023) The report highlights the government's objective of leveraging AI in smart infrastructure and urban planning. This infrastructure aims to optimize resource utilization, reduce waste, and contribute to a lower carbon footprint in India, thus creating a blueprint for sustainable urban development ("IndiaAI 2023: First Edition, By Expert Group" 2023).

Financial Access

India's financial sector priorities centre on several key initiatives to boost credit access, enhance consumer protections, and promote financial inclusion with the integration of AI technology. One notable objective made clear by the government is harnessing AI for fraud detection and risk management, which is becoming increasingly crucial as digital transactions expand ("Union Budget 2023-2024: Priority 7: Financial Sector" 2023). AI and ML technologies can conduct swift analysis of extensive datasets to pinpoint fraud-related anomalies and patterns, thus bolstering financial safety and trust for individuals and businesses (Kumar 2023). However, the Economy Advisory Council to the PM's report in December 2023, which provided an overview of financial market mechanisms in India, emphasized that AI technology must be treated with enhanced controls to avoid cascading regulatory failures in Complex Adaptive Systems (CAS) (Sanyal, Sharma, and Dudani 2023).

Moreover, the government aspires to democratize financial advisory services with AI, extending them to a wider demographic. ML algorithms will assess individual financial goals, risk tolerance, and market conditions to offer personalized investment strategies, helping people make informed decisions regardless of their financial knowledge. AI-empowered, automated trading can also usher in heightened efficiency and more robust risk mitigation strategies, contributing to market stability (Kumar 2023).

Education

A fundamental objective outlined in India's National Education Policy in 2020 is the personalization of education through AI tools. The vision is to apply AI to tailor educational experiences to students' individual needs, linguistic contexts, and abilities, as well as reduce the educational attainment gap. This initiative also aims to prepare a technologically proficient

workforce, capable of contributing to and benefitting from India's growing AI-driven economy("IndiaAI 2023: First Edition, By Expert Group" 2023).

3. India's Comparative Advantages & Disadvantages in Artificial Intelligence

India's AI policy strategies are shaped by its comparative advantages in the nascent AI industry, influencing both investments and perceptions of domestic strengths. This section reviews India's AI ecosystem assets – data, software, digital infrastructure, computer power, skilled labour, and R&D investment. It also assesses where India perceives its strengths and evaluates the likely regulatory focus, based on these advantages.

3.1 Data Availability

India possesses a significant advantage in terms of data availability. This is attributable to two factors: the large volume of data collected within the country for various national projects, and the relatively permissive privacy laws in India. The Indian government's consistent vision and strong control over the country's data management protocols, through the National Data Governance Policy, has positioned India well to harness this vast volume of data for tech advancements and innovation (The Hindu Bureau 2023).

India's robust information technology sector, combined with its access to datasets on diverse domestic populations, serves as a helpful springboard for its aspirations to be a global leader in AI. In this context, the Indian government has been inclined to facilitate access to its massive datasets for engineers to train domestic AI algorithms.

India's political use of data has led to skewed data collection for political gain, particularly in rural areas with low internet access. This results in lower-quality, non-representative datasets, leading to inaccurate analyses on issues like poverty, development, and disease control. Such misrepresentations compromise data accuracy and distort algorithmic models ("India's Once-Vaunted Statistical Infrastructure Is Crumbling" 2022).

Despite this, India's extensive data collection and current data management protocols are viewed as competitive advantages domestically, albeit with gaps in data collection. Consequently, the Indian government is likely to implement AI regulations or soft policies and programs related to data management, which allow them to leverage this advantage.

3.2 Software, Digital Infrastructure, & Compute Power

India's long-standing focus on its software industry, dating back to the 1990s, has established a significant comparative advantage in AI. This investment has made India a key player in global software development, providing a strong foundation for leadership in AI and machine learning technologies, including the possibility of improving India's place in the semiconductor value chain, should India pursue more opportunities in chip software design (Sun 2023). Targeted initiatives can

transition the existing workforce and software supply chains towards AI-centric projects, capitalizing on India's software expertise.

Additionally, India's digital public infrastructure (DPI) is a strategic advantage for AI development. Substantial government investment in DPI, including the Aadhaar digital identification program and a comprehensive digital payment system, has earned international acclaim. This robust digital infrastructure positions India to accelerate AI deployment and innovation on a global scale. The success of India's DPI, acclaimed at forums such as the G-20, offers a unique opportunity for India to leverage its existing digital infrastructure to accelerate AI deployment and innovation on a comparable scale (Kant and Mishra 2023).

However, building a robust AI industry requires substantial hardware, including advanced computational resources, like high-performance central processing units (CPUs) and graphics processing units (GPUs), and expansive data centres for algorithm training. India's hardware ecosystem lags behind, lacking the infrastructure to fully support indigenous AI development. Moreover, the capital-intensive nature of establishing a competitive AI supply chain, especially against established global players, underscores the need for substantial investments and strategic foresight in India's journey towards becoming a formidable force in the global AI supply chain.

In recognizing the limitations of the country's current computational infrastructure, the Indian government is actively seeking foreign investors to establish semiconductor manufacturing facilities in-country. This effort follows the government's announcement in 2021 of the $10 billion "Program for Development of Semiconductors and Display Manufacturing Ecosystem in India." ("Cabinet Approves Programme for Development of Semiconductors and Display Manufacturing Ecosystem in India," n.d.) Since the launch of the program, the government has allocated $2.75 billion to a Micron facility in Gujarat, matched with a $825 million investment from the U.S. company (*Reuters* 2023). Most recently, in late February 2024, India approved over $15 billion to build three semiconductor plants – although, notably, the plants will not produce advanced chips needed for AI foundation models (J. Singh 2024).

Additionally, U.S. chipmaker Nvidia announced AI partnerships with Indian companies Reliance Industries and Tata Group in 2023, focusing on cloud infrastructure, language models, and generative applications ("IndiaAI 2023: First Edition, By Expert Group" 2023). Moreover, Meta has signed a Memorandum of Understanding with 'India AI,' part of the Ministry of Electronics and Information Technology (MeitY), to foster AI development in India through collaborative efforts and the use of Meta's open-source AI models ("Forging Partnerships to Advance AI Technologies in India" 2023).

In general, India has a comparative advantage in software and digital infrastructure, and a comparative disadvantage in compute power, which is improving. Given the country's uneven strengths in these domains, we expect the government will introduce incentives to attract more of the semiconductor value chain in-country, lightly regulate these fields to allow private sector companies to build out its AI ecosystem, and incentivize software engineers to focus on ML-based technologies.

However, if India prioritizes expanding its hardware available for inference training and edge workloads, it may not need extensive domestic AI infrastructure to gain an edge in use-case applications. So far, it remains to be seen which of these goals will take precedence by the Indian government.

3.3 Skilled and Knowledgeable Labor

India's success in IT exports and software production over the past 30 years has positioned the country to have skill overflow into AI research, design, deployment, and management (Kapur 2007). In 2021, 34% of Indian graduates held STEM degrees, and the country currently has the largest STEM workforce in the world (Buchholz 2023). These professionals have skills in coding, advanced computing, software design, engineering, mathematics, algorithmic processing, data science, and other areas that are crucial to the advancement of machine learning. India has also developed a large pool of workers well-versed in English – another advantage, considering most LLMs today are trained in the English language (Kapur 2007).

To harness these skills domestically, India will need to bridge the gap between the current STEM expertise and the upskilling needed for these groups to enter the AI workforce (Bhatia 2023). Although there have been some university curriculum shifts to assist with this transition, the government could choose to mandate course requirements or play a more involved role in supporting national educational efforts to equip India's STEM graduates with hard skills for AI positions (Desouza and Somvanshi 2019). Additionally, India will need to work on retaining STEM talent within its borders. Today, there is a high rate of emigration from India for higher-paying STEM positions or graduate-level STEM education in other countries, especially in the U.S. (Choudhury, Ganguli, and Gaulé 2023).

AI advancement relies on more than just highly educated STEM professionals; lower-skill roles, like data labelling, are also crucial. India has emerged as a key hub for data labelling, providing employment opportunities for its large, unemployed youth population (Subramanian and Felman 2022) and enabling more women to enter the workforce (Ray 2023). Available labour is currently an abundant resource in India; however, the country may face challenges in transitioning its population away from agricultural positions and upskilling toward AI-oriented opportunities. What's more, much of India's IT labour force works in jobs that may be automated by AI, threatening massive economic disruption in the technology services sector.

India is considering wide-scale investments in upskilling or reskilling initiatives as a policy response. One segment of the AI workforce where India faces an acute shortage is in data centre personnel, which are crucial for cloud services and AI application deployment. India's tech giants like Wipro and Tata Group are already working to reskill their large workforce to adapt to AI technologies, yet it is too soon to tell if such investment will prevent or minimize the perceptively inevitable economic disruption (Yu 2023).

India has a significant comparative advantage in skilled and unskilled labour available for work in AI advancement, but this advantage is not absolute - India still has gaps to fill in its AI workforce that will require government programming.

3.4 Research and Development (R&D)

Today, India struggles to prioritize its AI R&D, which is vital to producing competitive algorithmic models, sectoral ML experts, and a diverse, skilled labour pool for success in this field. Among other BRICS countries, India ranks last in R&D investments (JC 2022). India's lack of investment in R&D is a critical shortcoming in the state's ability to build cutting-edge models and develop a competent workforce in emerging technologies.

Furthermore, India lags behind other countries in prioritizing government R&D funding, specifically towards developing sovereign advanced models. Despite discussions about increasing funding, there is scepticism about India's ability to develop competitive foundation models. It seems so far, India will most likely favour other areas in AI development, due to the lower government priority placed on advanced models. Instead, India may favour developing AI applications that address tailored use cases, as opposed to catching up in the development of foundation models that can compete with other countries.

To summarize, India has a comparative disadvantage in government R&D for AI, but this status may shift as India seeks to become more competitive globally in some areas of AI development.

3.5 Favourable Business Ecosystem for AI Industry

Prime Minister Modi is making India the destination for global investment in the technology industry by enacting a variety of economic liberalization reforms, relaxing certain Foreign Direct Investment (FDI) restrictions, and promoting competition.

In 2014, Modi launched the 'Make in India' initiative aiming to draw the attention of businesses throughout the world to invest and manufacture their products in India (Nagarjuna 2022). Key to Make in India's success is promoting ease of investment, particularly FDI, by minimizing regulatory hurdles, while offering attractive physical and human capital resources. Going further, the "Digital India" and "Start-Up India" programs not only present avenues for greater expansion of the technology sector but also bolster the start-up ecosystem to encourage indigenous innovation (Slover 2023).

Consequently, global entrepreneurs, notably in the technology sector, have turned their attention to India's convergence of inexpensive skilled labour and start-up-friendly policies. U.S.-based Vivek Wadhwa, for example, moved his biosciences AI start-up from Silicon Valley to India, where "*rather than creating hurdles with regulation, restricting immigration, and suffocating the tech industry, [the government] is establishing a new fund to support its AI ecosystem*," and will "*do whatever it takes to facilitate entrepreneurship... support startups and ... welcome foreign companies.*" (Wadhwa 2023).

Also, MeitY's jurisdiction extends to Software Technology Parks of India (STPIs), which promote various technology industries, including AI and ML, by providing a startup ecosystem that facilitates

collaboration between government, industry, academia, and other stakeholders ("About Software Technology Parks of India (STPI) | Software Technology Park of India | Ministry of Electronics & Information Technology Government of India," n.d.). In harmony with the government's AI industry-enabling policy directives, India's massive multinational corporations are investing greatly in India's AI-leading potential.

- Wipro, an IT consulting services company, plans to invest $1 billion in AI over three years not only for its own business, but also to identify and absorb generative AI startups through the Wipro Ventures accelerator (Yu 2023).
- Meanwhile, Tata Group and Reliance Industries, both multinational conglomerates with involvement in just about every industry possible, have each partnered with U.S.-based chipmaker NVIDIA to bring AI capabilities, "within reach of thousands of organizations, businesses and AI researchers, and hundreds of startups in India." ("Tata Partners With NVIDIA to Build Large-Scale AI Infrastructure" 2023).
- Finally, Infosys, India's second-largest exporter of software services, entered into a $2 billion deal to build out AI capabilities across five years (*The Times of India* 2023).

India's big tech companies are combining financial investments, strategic partnerships, and ecosystem development to position themselves as leaders in AI technology, rivalled only by the U.S. and China. Therefore, the Indian government's objective of enabling a flourishing domestic AI industry is another significant comparative advantage in AI. We anticipate the government will continue to lean on this advantage in building out its AI capabilities going forward and it will avoid AI regulations that stifle business in-country.

4. India's Likely Approach to AI Governance

4.1 Central Research Takeaways

Through our research in New Delhi and Bangalore, we received a wide breadth of feedback on how India will likely structure its AI regulations to help the country meet its innovation-based priorities. Based on our findings, and research on other countries leading in AI governance, we believe India will situate itself in the following spectra regarding the choices it faces for AI governance domestically:

Choice #1: A Centralized AI Governance Framework

Insight #1: The overall AI governance bias in India is not to regulate AI broadly, and instead prioritize innovation for developmental priorities. However, there will be some AI provisions incorporated into broad Indian technology laws that apply to all AI-based systems.

India is unlikely to create a fully centralized AI governance framework, but will incorporate provisions into legislation that apply to all AI-based technologies in India. Additionally, India will govern AI applications sectorally, through the regulatory bodies that set guidelines across healthcare, defence, education, finance, agriculture, and other sectors. At the same time, the government will prefer to use immediate executive action instead of legislation in areas where there are already perceived AI risks, such as content moderation and deepfakes.

Given India's desire to influence leading countries in AI innovation, Indian policymakers are pressured to regulate this space on the international stage. One technology leader we interviewed emphasized that "*we have an interesting opportunity in public policy to operate at the cusp of what's good for the private sector, the government, and the country.*"

Yet, India's distinct characteristics, namely its heterogeneity in languages and cultures, as well as its status as a developmental state, have prompted the government to develop regulatory priorities that differ from other tech-innovating nations. For example, a U.S. government representative posited that for India, "making money is not the goal, creating jobs and economic growth are the goals." In fact, there is an overwhelming position in India to expressly *not* follow in the footsteps of the EU's AI Act and the United States' efforts, as "*India, on the other hand, is clearly focused on making sure the innovation and impact of AI for good does not go away*," according to a representative from a large technology multinational company.

For example, a Delhi-based technology journalist reiterated that India is unlikely to make big moves in AI regulation anytime soon, given how nascent the generative AI ecosystem is domestically. Further, India's market is unique from any other country, given its great heterogeneity in ethnicities, languages used, and cultural makeup among its 1.4 billion population. While it has enjoyed incredible economic growth in the last two decades, India remains a developing economy with worsening income inequality, combined with less than 50% internet penetration (Petrosyan 2024).

In this context, to avoid stymying the fledgling AI industry, and to be responsive to the country's development priorities, India's policymakers are unlikely to enact comprehensive AI policy and regulation, but instead will update its existing laws. According to the journalist, the "*government aim is to have a balanced approach, have businesses nurture the economy, but the population gets their own control.*"

As this technology journalist mentioned, "*since general elections are on the way, they are trying to delay that move of updating their own IT Act and are now trying to update IT integrative rules.*" Thus, instead of a single, AI-specific bill, several stakeholders we interviewed highlighted three bills the Indian government will update in its efforts to be more responsive to the rapidly evolving digital space:

- **Digital Personal Data Protection Act (DPDP):** Passed in August 2023, after five years of redrafts, DPDP codifies how an individual's data may be collected and used, and includes the right for individuals to withdraw consent. The law applies to Indian residents as well as non-citizens living in the country. It allows for cross-border data transfers, enabling Indian data to be utilized outside of the country by non-Indian actors – unless the data is transferred to certain restricted countries or territories. It does not supersede other measures by government agencies that impose localization requirements. The DPDP exempts certain entities and purposes – including data processing necessary for research if personal data is not used in decision-making, as well as startups – from some potentially cumbersome compliance provisions (Burman 2023).
- **Digital India Act (DIA):** Intended to replace the Information Technology Act of 2000 to ensure "*openness, safety, trust, and accountability of the Internet*," notably addressing emerging technologies like AI and quantum computing (Chauriha 2023). This act has yet to be released for public viewing, and is slated for release in 2024. DIA is expected to contain greater consumer safety and data protection measures, and clarify liability of intermediaries hosting undesirable third-party content on platforms.
- **Telecommunications Bill:** Introduced in December 2023 and in effect as of July 2024, the updated Telecom Bill proposes far-reaching powers to control communication networks and penalizes unauthorized access to telecom network data.

While broad AI regulation was not implemented before the general election, as many of the stakeholders we interviewed anticipated, Modi's office has expressed dedication to being a global norm setter in AI policy, especially leading among its peers in the Global South. After the election, we expect to see the three updated bills reflect India's goals of regulating AI systems and access to data to serve national interests, as well as minimizing the dominance of foreign technology companies.

Whether these updates will be sufficient is a source of debate, but some of the technology lawyers we spoke to mentioned "*the absence of overarching legislation is worrying.*" Even some of the biggest private sector stakeholders we interviewed agreed and said it is "*important that there is some regulation…it cannot be kept completely open.*"

As of May 2024, MeitY representatives have indicated that the government is also considering additional AI legislation or statutes incorporated into the DIA that protect the rights of news publishers (Agarwal and Aryan 2024) and regulate deepfakes (Pandey 2024), which relates to our second insight.

Insight #2: India will largely govern AI applications sectorally, with special emphasis on deepfakes and content moderation. Also, India will implement restrictions reactively to perceived risks and harms caused by developing AI systems.

Stakeholders across the AI innovation ecosystem - from the private sector to civil society - confirmed India is not inclined to enact sweeping AI regulations. Instead, policymakers are focused on regulating particularly sensitive sectors that demand oversight to mitigate far-reaching harms that

are being observed. A high-ranking technology representative from an American multinational company confirmed that the "*government is quite clear that regulation is never going to come ahead of tech developments.*"

However, in India, the threat of deepfakes dominates most AI regulation conversations, especially deepfake applications used in social media and finance. Before the 2024 election, government concern surrounding the AI-enabled proliferation of deepfakes was front and centre, for its feared influence over democratic processes and public perception. Although the last administration was near certain that Prime Minister Modi would keep his seat, the government reminded social media platforms that it is illegal to post misinformation, going as far as threatening to block platform network access. The administration's fears were apt, given that competing campaigns made extensive use of deepfakes in the leadup to the 2024 elections.

These developments also highlighted significant gaps in AI-related legislation: although the IT Act makes it illegal to impersonate an individual, or transmit explicit material online, this law does not specifically target deepfakes. Accordingly, one area where the government seems unusually eager to regulate AI technologies is the use of deepfakes on social media. While many tech policy experts argue that using AI image generators for satirical political commentary is a form of protected speech (especially in the U.S.), Indian policymakers remain steadfast in banning the use of deepfakes. For example, a government representative we spoke to highlighted the threat of this technology by claiming that "*SMS chains and YouTube videos could set off riots on any Friday.*"

In place of regulation, a representative of a large American technology company underlined the tech giant's dedication to responsible AI, and reiterated its dedication to having open conversations with the Indian government to tackle deepfake-related issues. Multinational tech actors would prefer policymakers to not enact legislation that would make social media platforms criminally liable for hosting deepfake content on their sites, and are thus encouraging policymakers to avoid such measures.

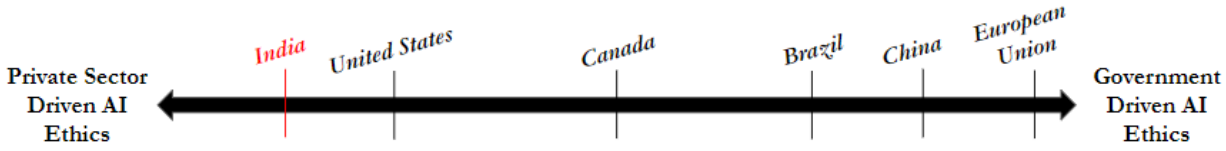
Nevertheless, Prime Minister Modi's office is pushing to make platforms criminally liable for hosting and proliferating deepfakes, through executive actions, with the threat of outright banning platforms if they fail to comply. This strategy was heavily critiqued by human rights and civil society groups we interviewed that said, "*while it does allow the government to make quick decisions, it bypasses democratic lawmaking.*"

Additionally, the Indian government is keen to implement stringent sectoral regulations for AI applications in finance. The financial sector has been the first adopter of security and regulatory measures in the face of emerging technology threats in India, and the case of AI integration is no different. Since India has one of the largest and fastest-growing fintech industries globally, on top of the incredible success of the DPI-enabled universal payments interface (UPI), many of those surveyed in our research pointed to the financial services sector as a priority for sectoral AI regulation.

A few domestic model developers in India highlighted that finance is a "*high-risk sector*," and by "*broad definition, regulations (in finance) will have a consequential impact.*" Noted threats include

deepfaked voices to "trick" biometric security checks, as well as discrimination perpetuated by biased algorithms to determine creditworthiness. Also, public expectations for the AI safety of this sector seem higher, and an AI consultant we spoke to mentioned that "*loan applications are a concern in the finance sector...the government has a responsibility to citizens that they do not get scammed...it's a maximalist protection approach, similar to China.*"

Choice #2: Defer to the Private Sector to Shape AI Ethics



Insight #3: The Indian government will predominantly defer to the private sector to create AI development restrictions and shape AI ethics domestically, while providing some fundamental guidelines through governmental AI strategy reports. Yet there are some areas of AI development led by the government that are already publicly contentious and are gaining more attention in India. Whether the government decides to set harder limits on these AI use cases remains to be seen.

India is likely to take a predominantly hands-off approach to restricting AI development, and will largely rely on the private sector to determine which applications are worth pursuing in India – and which should not be pursued. However, this expectation comes with the caveat that the Indian government will have more explicit restrictions for automation in some sectors, and will reactively set limits for AI development if there are perceived harms for the public or risks to public order. For instance, there have been more restrictions set for automated loan applications in India's finance sector, since there was rampant over-lending and debt exploitation through these platforms during the COVID-19 pandemic.

One technology expert we interviewed stated the government "*wants to be a facilitator and work with companies and make these regulations so Indian companies can come together, work together on public problems.*" At the same time, the government will likely play a slightly more involved role in constraining AI development domestically than the United States, since there are certain applications which the government would like to restrict when used outside of government programs, rather than letting the private sector dominate.

For example, one area where AI applications are being developed predominantly by the government and becoming publicly contentious is the use of Facial Recognition Technology (FRT) in public surveillance systems. FRT has seen increased usage by Indian law enforcement agencies and airports across the country. Ameen Jauhar, Senior Resident Fellow at the Vidhi Centre for Legal Policy, posits that the widespread adoption of FRTs by the police (across states) in India is a result of the techno-optimism within the establishment and "*function creep*," occurring across Indian agencies.

Jauhar provides the example of Delhi Police practices, which initially used FRT to identify missing children, but now applies this technology to criminal investigations. In his own words, "*(there has been a) significant detour from its prescribed usage,*" in the case of FRT in India. He argues this "*detour*" is particularly dangerous, due to the lack of regulatory guardrails, and researchers at another Bangalore-based think tank mentioned the "*policies that ideally should be in place to ensure consent while sourcing facial data from people and the way it's been processed is transparent and accountable aren't in place.*" Also, as one public policy manager at a U.S. tech giant succinctly put it, "*there simply aren't sufficient restrictions on FRT.*"

Through our interviews, we learned that the absence of regulations for this technology is not a function of the nascency of the AI field or bureaucratic ineptitude, but rather stems from deliberate government inaction. Jauhar describes the increased use of FRT in surveillance as "*happening inside an administrative black box.*" For instance, three new bills were passed in the latest parliament session, replacing British-era criminal codes (V. Singh 2023). Yet FRT usage and the admissibility of evidence secured through these technologies were simply not mentioned in these bills.

Per Jauhar, Right to Information (RTI) requests looking into internal memoranda and rules for government FRT usage have been rejected as well. He claims that there is thus a "*clear intention on the part of the state to cover its tracks and give it as much leeway as possible*" when it comes to the collection and processing of personal information for "*public order.*" This sentiment was shared by other legal experts we interviewed, who mentioned the "*Data Protection Act language has granted sweeping exemptions to the government for collection and processing personal information for public order and national security,*" which is "*likely to be mirrored in any restrictions created for AI applications as well.*"

Furthermore, the judiciary has been advocating for the incorporation of AI systems into its daily operations, aligning with the broader trend of integrating conventional information technology to digitize democratic processes. In this context, the Supreme Court of India has introduced SUPACE, the Supreme Court Portal for Assistance in Courts Efficiency, an AI portal designed to gather and analyse data from the numerous backlogged cases within the Indian judicial system. Additionally, the court has launched SUVAS, the Supreme Court Vidhik Anuvaad Software, serving as a translation tool for court documents (Saha 2022).

Jauhar emphasizes that although these advancements may appear advantageous on the surface, a delicate balance exists in implementing technology to enhance judges' efficiency without replacing their decision-making capabilities. He asserts that AI is "*definitely displacing human judgment,*" citing an instance where a judge reversed their instinctual decision to grant bail after conducting research using ChatGPT.

As these AI use cases spread, the government seems to be in no hurry to impose regulations that will hamper the performance of state functions. Jauhar expanded on this development and suggested that while the government will regulate the use of surveillance technology in the private sector, it will seek to exempt itself from any restrictions. He predicts that FRTs will remain unregulated, as the

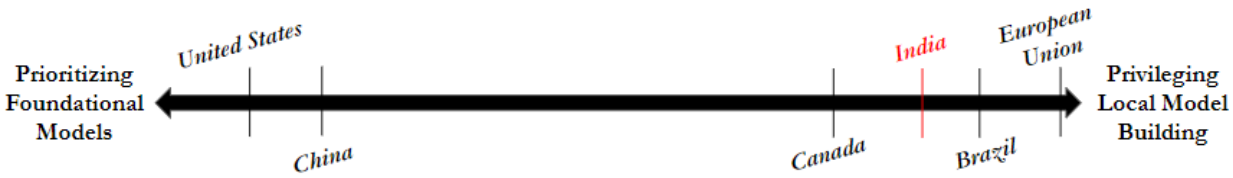
government awaits potential legal challenges for any future developments; the government's preoccupation with achieving developmental outcomes requires them to forgo regulations in the short run.

Other civil society stakeholders we interviewed offered a slightly different perspective on the efficacy of public opinion and pressure points on AI ethics in-country. One of the ethical AI institutes we interviewed mentioned that "*lawyers within the judiciary system are putting pressure on the government to set limits on this technology's use, and groups like the Internet Freedom Foundation are advocating for greater public digital rights in India.*" Additionally, "*field experts that serve on government AI committees are pushing for change in legislation and public requests for comments on papers produced by NITI Aayog are other avenues for pressure, where comments from experts and critiques on ethical AI are shared with policymakers.*"

Moreover, the Indian government seems unlikely to provide additional AI ethical norms beyond strategy reports produced in collaboration with the private sector, which provide guidelines for responsible AI, and commitments made through global dialogues like the GPAI. As established throughout this report, the Indian government has produced several national AI strategy reports, in coordination with the private sector and civil society, that espouse guidelines for responsible and ethical AI.

Yet beyond these reports, Indian stakeholders believe the government will continue to defer to the private sector to shape AI ethics domestically. Further, the nongovernmental organizations and legal experts we spoke to who specialize in AI ethics in India stated that the "*government's priorities are around innovation and human rights take the back seat*," and "*the government strategy seems to be to push the technology first and address the harms later.*" Therefore, the Indian government may slightly shape AI ethics in-country, but the private sector will largely guide these norms. India has put forward more ethical AI directives through groups like NITI Aayog than Canada, but we do not anticipate the government creating a comprehensive document like the United States' "AI Bill of Rights."

Choice #3: Prioritizing Local Model Building & Data Localization



Insight #4: India seeks to become the AI use-case capital of the world, and wants to prioritize local model building – that will serve its population's needs – over foundation model development.

India is interested in prioritizing data localization and population-specific ML models to meet its developmental priorities, but some larger Natural Language Processing (NLP) models will also be used domestically to help with innovation. A representative from one of the large tech multinationals

in India explained the government aims "*to use service centres that penetrate in rural areas so training sets are as localized as possible*," but the government recognizes "*that U.S. tech companies have user data from around the world that new companies lack.*"

To help build out the AI industry locally, India will leverage the NLP capabilities of foundational models created in other countries to assist with translation and language capture across platforms, but ultimately, the government seems likely to restrict model building and dataset usage so that they are representative of Indian communities in use-case applications.

India's ambition to become the "AI use-case capital of the world" is evident in its model localization initiatives, tailored to meet its population's needs, and selective AI-application developments. A Delhi-based journalist we spoke to stated that the government is "*looking to limit biases and make things easier for localization and use Indian culture and Indian wants, especially targeting Indian customers.*" For example, this commitment is reflected in the government's recent efforts to enhance the Unified Payments Interface (UPI), by focusing on issues like data portability to improve its functionality for users across different regions of India.

A prime example of India's frugal approach to model building is the development of "Bhashini," an India-specific LLM designed to capture the linguistic diversity of its population, thereby creating AI solutions that are not only technologically advanced, but also culturally and contextually pertinent. Many stakeholders we interviewed within India anticipate firms overlaying language programs like Bhashini with other AI systems developed for specific computational goals in India, like agricultural production analysis. This strategy diverges from other AI-focused countries that are prioritizing the development of large foundational models for general-purpose use.

To execute India's goal of creating robust AI models specifically for India, Rahul Matthan, a Bangalore-based technology lawyer, emphasized how crucial it is for the government to establish clear regulations around open-source data and fair-use policies for Indian model training. Such legal clarity would facilitate public innovation and safeguard intellectual property rights. Addressing copyright concerns is key, since AI frameworks allowing fair-use exemptions could encourage innovative AI application development domestically by easing copyright violation concerns.

Additionally, Matthan mentioned India should leverage the linguistic wealth of the "*Indian National Broadcast, which produces content in various regional languages, nationwide, every day.*" However, this project would require creating a cooperative framework that allows private sector access to these resources and encourages content creators to share their work.

A representative from a large technology company agreed and said, "*traditional legal concepts are going to be shaken up related to AI developments…we have to reimagine IP rights, opt-out rights, etc.*" They also mentioned India can improve the resiliency of its models in different use cases by exploring more red teaming exercises, where experts attempt to "break the models" through experimental hacking. By exploring the vulnerabilities in India's ML systems, stakeholders like the Data Security Council can ensure AI-based services remain operative and effective for its domestic population.

Overall, the government's involvement in select AI projects demonstrates its genuine intent and capacity to implement significant technological advancements for its population, far beyond mere strategic posturing. By embracing its potential role as the AI use-case capital of the world, India's approach not only advances technological prowess, but also crucially integrates a significant sector of its population into the digital economy. This integration paves the way for communities to access higher levels of economic opportunity, bridging the digital divide, and fostering inclusive growth across various sectors of the Indian economy.

Choice #4: AI Infrastructure Development

Insight #5: The Indian government wants to play a central role in building AI infrastructure domestically, including cloud platforms, data collection centres, and computational facilities. However, the government's capacity to meet these objectives and implement a Digital Public Infrastructure (DPI)-style approach to AI is yet to be determined.

The Indian government wants to provide more AI infrastructure than most countries today, but their capacity to do so was an area of disagreement among the experts we interviewed in our research. In general, there is interest in India to take the success of DPI initiatives the government created through the G-20 and translate that infrastructure model to AI, or a "DPI for AI" approach. Yet this government intervention and capacity-building method will demand immense amounts of capital to create computational facilities, data collection centres, and cloud platforms, which the government may not have independent of private firms.

Based on our research, a DPI approach to AI appeals to the government for the opportunity to leverage its unique data-sharing protocols across agencies and translate that advantage and cache of data into machine learning capabilities catered to Indian populations. This approach would also allow the government to be the source of AI innovation domestically through infrastructure development and level the playing field for competitors, rather than solely relying on tech multinationals to dominate this infrastructure space.

Additionally, some of the civil society groups we interviewed said that "*DPI is a powerful tool for diplomacy and data sovereignty.*" The U.S.-Indian Business Council (USIBC) mentioned these projects could also provide "*infrastructure to build on*" so that new AI companies can continue to expand the government's efforts.

Although one of the government's model-developing partners mentioned several cooperative initiatives are ongoing, and the government is making its existing computational infrastructure more accessible and efficient, they also stated that "*setting up infrastructure will be fundamentally different*

for AI." These initiatives will require large quantities of capital that the Indian government may simply not be able to provide. However, if the Indian government leans on the private sector or other AI consortiums to provide this capital and tailors its hardware build-outs for use-case application training, its ambitions will be much more achievable.

A journalist documenting these types of investments mentioned AI infrastructure "*requires a lot of capital…not sure the government has the money for this experimentation.*" Another ML engineer helping the government with regulations shared this perspective and said, "*the government is not going to be involved in indigenous compute infrastructure, but as long as it's stable, it doesn't matter if it comes from a cloud provider…if tech service providers build the infrastructure on existing cloud service providers…it unbundles the market to different players that provide services…building standalone infrastructure is very tough.*" He also argued that these cloud service providers will make solutions cheaper for SMEs.

U.S. representatives shared this sentiment and said "*we can address a few issues here and there, but we can't compete with the money big tech throws around.*" Additionally, one of the legal experts we interviewed mentioned the India Data Management Office (IDMO), which was created for DPI national data sharing, still faces barriers to making its resources useful. They stated, "*access to data is not easy, and the quality is also not always good.*" They also argued there "*is no government capacity for large-scale data collection for AI*," and pointed to Microsoft building the country's agri-stack to get the project off the ground as an example.

However, there are several promising areas of government-led infrastructure development that indicate they are taking this priority seriously. For example, the government's Open Network for Digital Commerce (ONDC) ("About: Creating an Inclusive Ecosystem for e-Commerce" 2024), which "*operationalizes fair play*," has brought in multinationals to implement this program and create a digital highway for network access. Furthermore, participating companies must ensure they follow privacy protocols used traditionally in DPI. Also, local AI nonprofits have mentioned that "*capacity building for community Wi-Fi in villages is ongoing*," which is improving connectivity and data collection capabilities in rural areas of India.

Another domestic consulting group working on AI projects argued the government intends to build out the infrastructure it can – a directive coming directly from the Prime Minister's Office (PMO). They stated, "*The government is funding multiple research projects which are also run by private companies…these include GPU clusters and clients building a sovereign cloud.*" Additionally, they mentioned, "*there will be a government bias toward creating indigenous compute (infrastructure).*" The scale at which the government can pursue its infrastructure goals is yet to be determined, but the possibility of this development is certainly contentious in India.

4.2 Implications for the U.S.-India Bilateral Relationship

Our research revealed several critical implications for the U.S.-India bilateral relationship related to AI governance. First, India is positioning itself to be the "AI leader of the Global South," yet will

likely continue to rely on U.S. infrastructure needed in the early stages of the AI value chain, such as compute power.

India's reliance on data exchange and computational services from American technology firms could become further complicated, should India decide to build out AI infrastructure in a DPI-style manner. This relationship could also be strained by trade restrictions the U.S. places on India, including export controls on supercomputers (Wolcott, Homer, and Goodman 1998), the International Traffic in Arms Regulations (ITAR)'s "dual-use" technology classifications ("Amendments to the Export Administration Regulations Implementing an Additional Phase of India-U.S. Export Control Cooperation" 2017), and emerging AI chip export controls (Sevastopulo and Reed 2023).

Second, the U.S. and India are developing complementary AI governance strategies, despite some tensions over how India is approaching deepfakes and content moderation. Finally, India's emerging AI ecosystem offers advantageous investment opportunities, unique machine learning resources and applications, and a positive outlook regarding AI's potential, which are all appealing to U.S. stakeholders.

India wants to be an AI governance leader for the Global South, and will pursue opportunities to export its AI applications and governance model, to expand its G20 influence. India wants to lay the foundation for other developing countries creating AI governance frameworks, which could allow them to leapfrog technologically and capitalize on their available resources. For example, India sees its approach to developing AI tools for specific use cases as a comparative advantage that can work in other developing nations.

Similarly, India views its model of AI governance, which promotes indigenous AI startups and capitalizes on the diversity reflected in its data, as an impactful governance model that can be exported to other countries. One government ministry even stated that "*technology can be a great divider or great enabler for international development and collaboration, AI can enable the bridging of technology gaps, and the Global South should be considered in the regulation conversation.*"

Furthermore, in an interview with an executive from a large U.S.-based tech firm operating within India, **it was made clear after 2023's G20 summit in New Delhi that India holds a much more significant role in the Global South in the realm of AI governance**. The summit opened conversations about how India could expand upon the GPAI to facilitate the creation of such AI frameworks in the Global South. However, it is important to note these forums take time to solidify a consensus among willing nations. A high-ranking Indian government official reinforced this vital caveat, mentioning the lengthy negotiation process before the successful agreement of a new resolution on AI at the 2023 GPAI in New Delhi.

Yet, unlike its AI framework of governance, which is ripe for dissemination, **Indian experts we interviewed are sceptical of India's ability to export actual AI technology to other nations.** A prominent technology lawyer in India mentioned how improbable it would be for India to export its

indigenous AI startup technology elsewhere, implying that the LLMs being created in India lack both the sophistication and adaptability that U.S. LLMs already excel at.

Thus, there are no clear advantages to India exporting aspects of its AI technologies to other countries. On the other hand, another Indian multinational representative stated, "*India has realized that the domestic market is not enough…the last three and a half years, we've moved from a country shying away from trade policy conversations in AI to very active trade policy conversations.*"

However, a lawyer we interviewed discussed the **possibilities of exporting DPI technology and solutions to other countries, mentioning discussions they had with the government of Brazil a short time before our interview**. Other nations have a clear interest in building out a DPI framework like the one existing in India. These initiatives to build such DPI in other countries would allow India to promote the indigenous technology that made its DPI successful, which may eventually be integrated with other AI systems. It could also provide pathways in negotiation and discussion surrounding the promotion of its aforementioned AI frameworks.

Additionally, the U.S. and India are, in broad terms, developing complementary AI governance strategies. So far, India and the U.S. are deferring to the private sector to predominantly drive AI developmental constraints and ethics; participating in AI governance forums, like the GPAI, to harmonize regulatory values; prioritizing infrastructural improvements to support nascent businesses; and using sectoral regulations to ameliorate user harms. Moreover, India is establishing itself as the AI application "use-case capital of the world," and is doing so by being comparatively lax in its approach to data privacy to bolster AI application development.

While the government of India exhibits an "*Indian bias*," giving Indian companies preferential access to AI inputs, American companies also enjoy great opportunities in the AI applications realm. Exemplifying this relationship, the Microsoft representative we spoke to pointed to the nearly 15,000 Indian partners that "*build solutions on top of our technology.*"

Despite their converging goal of prioritizing AI innovation through programs like the initiative on Critical and Emerging Technology (iCET), the U.S. and India are still facing some pain points in their bilateral relationship related to AI development. According to several State Department officials based in Delhi, content moderation and deepfakes are a contentious issue between the Indian government and American technology firms. The Indian government's restrictive approach in these areas, which we previously highlighted in this report, means American technology firms could incur large costs if AI-generated content proliferates across their sites.

Depending on the executive actions the Modi administration takes related to deepfakes and platform accountability, social media firms may choose to change their business involvements in India and close their AI-related projects. However, we cannot confirm with certainty how the U.S. and India's different approaches to content moderation and deepfakes will widely impact the AI corridor between these nations.

India's emerging AI ecosystem may offer advantageous investment opportunities and appealing machine-learning resources for U.S. companies. India's comparatively relaxed regulatory

environment is opening opportunities for businesses and state partners to invest in AI start-ups domestically, where they may not thrive in areas like the EU or China. Also, India's large supply of data and streamlined data-sharing protocols are resources that American tech multinationals are interested in leveraging to develop new models and products.

Furthermore, consistent optimism amongst the public, civil society, the private sector, and policy officials related to AI's potential to positively impact Indian society distinguishes the country from other states; despite some exceptions related to surveillance systems, Indian stakeholders consistently mention they believe AI will be a fundamental good to help the country succeed. Each of these facets of the AI ecosystem in India are driving partnerships between the U.S. and India and could improve relations related to AI development.

However, India's reliance on data exchange and computational services from American technology firms could become further complicated, should India decide to build out AI infrastructure in a manner similar to DPI. To date, India's nascent AI industry relies heavily on U.S. tech giants, like Microsoft, for crucial ML elements and program implementation, such as data processing, model building, and computing power. In the same vein, U.S. companies are highly dependent on Indian labour for IT outsourcing for tasks such as data labelling and software engineering. If the Indian government decides to take a more prominent role in creating cloud components, data centres, and other AI infrastructure, these actions may displace American business or prompt friction with renewed government oversight.

Some of the experts we interviewed also asserted these interventions could alter the monopolistic status that American tech firms have over the industry. In fact, the government may, through data localization mandates, choose to withhold newly-collected data caches or access to cloud and computing facilities they create in order to benefit localized industries. Also, the government may require specific data exchange transfers from tech companies to operate in India if they want to use localized data, thereby levelling the resource playing field and improving the training capacity of Indian models. With that said, as India shifts away from being the "*world's back-office*," American companies may find themselves collaborating with the Indian tech industry rather than simply outsourcing their IT needs.

Despite optimistic declarations of portending India's rise to AI dominance, **large American tech companies may already be inadvertently serving as gatekeepers for Indian AI developers, given the dearth of Indian companies with advantages in the chips and computing infrastructure layer of the AI stack, and reskilling issues**. The challenge of AI innovation concentrated amongst a few American big tech companies is concerning for the American government as well, as exemplified by the recent Federal Trade Commission's inquiry into potentially anti-competitive partnerships between Microsoft and OpenAI, Amazon and Anthropic, as well as Alphabet and Anthropic (Graham 2024). Depending on the outcome of this inquiry, the decoupling of big tech and a few select AI developers could very well have downstream effects for the Indian tech industry, including

opening up the Indian market to greater R&D investment flows, greater competition for cloud service providers, and different access to AI chips.

One of the American technology representatives we interviewed in India confirmed the government hopes these multinationals can help with reskilling efforts and "*expects a lot of industry to be able to help with the ecosystem...capacity building for the workforce as soon as possible, so the next generation getting into the tech space should be AI ready.*" Clearly the interdependence between India and the U.S. in the AI industry creates opportunities for jointly-driven innovation, but it may also introduce potential friction points. Both countries are still navigating their national interests and collaboration to ensure the long-term stability and success of their AI pursuits

In this dynamic landscape of emerging technology, the collaboration between the United States and India is a strategic imperative for both nations. A common thread in our conversations revealed a shift in how these countries approach their relationship with technological innovation, as India moves beyond scaling and deploying foreign technologies and instead collaborates with U.S. firms to build its own development-oriented innovations. In strengthening this bilateral system of positive technology transfer, India will establish itself as an innovator for countries in their development journeys, leveraging its deep talent pool cultivated by decades of American investment.

While there is some scepticism about how much of the AI value chain India can build within its own borders, it is all but certain India will emerge as a technology superpower to contend with. In terms of the U.S.-India relationship, this strategic alliance – and mandate to decouple from China – will be a linchpin for fostering economic resilience, compensating for trade shifts, and shaping the future trajectory of the global technology sphere.

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Augmenting Use of Technology in Implementation of NFSA-2013: Documenting Evidence From Assam

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Abstract

Technology has the potential to help governments live up to their ambitions for public policy and delivery. To increase the efficiency of the Public Distribution System (PDS), the Government of India has launched multiple Information and Communication Technology (ICT) intervention projects under the National Food Security Act (NFSA), 2013. The article looks at the effectiveness of Aadhar Seeding, Biometric Authentication Systems, Fair Price Shop (FPS) Automation, Integrated Management of Public Distribution Systems (IMPDS), Mobile Applications (Mera Ration App), and Direct Benefit Transfer (DBT)- in enhancing transparency, accuracy, and accountability of PDS under NFSA, 2013 in the delivery of subsidized food grains in Assam. The study relies on secondary data. The augmentation of technology has the potential to increase the effectiveness, transparency, and accountability of the NFSA implementation and address the issue of food security. The authors suggest that ensuring the feasibility of FPSs, creating dashboards for data and reports for NFSA stakeholders, conducting social audits, and developing efficient monitoring and evaluation frameworks within the NFSA can greatly improve the efficiency of the PDS in Assam.

Keywords: NFSA- 2013, Public Distribution System, Assam, Technology, Development, Food Security

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1. Introduction

In the past few decades, the progress of human development has been accompanied by rapid technological advancements and an increasing proliferation of digitized gadgets and services. This provides extensive databases to help policymakers with policy creation, formulation, and evaluation. Technology has the potential to help governments live up to their ambitions for public policy and delivery.

Due to a lack of expertise, infrastructure, and training, a sizable portion of the population in developing nations continues to have no access to ICT services (Chhabra, 2020). In a country like India where people in rural areas lack basic amenities like safer food, water, sanitation, electricity, and proper roads, Information Technology (IT) can be used as a public policy tool to mitigate some of the administrative problems. IT can weaken the information asymmetry prevalent in the countryside by providing timely information to its citizens (Ashraf, 2004).

According to the United Nations, Conference on Trade and Development (UNCTAD) five 'A' s of technology are essential for the effectiveness of the usage of technology in day-to-day life: the availability of technology is available in the place where the person lives, affordability that price of the technology is affordable, awareness about the technology people are aware of the ways that the technology is relevant to their lives, accessibility is also important that the technology is accessible considering the language and physical conditions of users, ability that means appropriate user skills to translate technology access into valued development (UNCTAD, 2021).

2. Transforming the Public Distribution System: A Journey of Evolution

The PDS is the most extensive planned food distribution scheme in the world. It was implemented as a national policy following the Great Bengal Famine in the early 1940s. To guarantee household food security in India, PDS is regarded as one of the most significant government-run schemes for providing subsidized food grains (Singh et al., 2020). The Five-Year Plans had a major role in the development and extension of India's PDS. One major move was the formation of the Food Corporation of India (FCI) in 1964. This initiative was critical in alleviating India's food crisis and formed an important link with the PDS.

Deaton and Dreze, (2009) highlight the importance of the PDS in addressing hunger and malnutrition but also underscore its inefficiencies, leakages, and targeting errors, which undermine its potential impact on food security. To overcome errors in PDS the Government of India revamped the almost universal PDS and launched the Target Public Distribution System (TPDS) in 1997.

The TPDS is India's largest safety net programme, both in terms of government expenditure and the number of beneficiary households. However, TPDS also has been subject to evaluation and

critique by scholars. Khera (2011) showcased the shortcomings of TPDS, emphasizing the need for reforms to mitigate leakage and improve targeting. Therefore, the implementation of the National Food Security Act (NFSA), in 2013 has been seen as a significant step, in terms of recognizing the 'Right to food' for citizens, and regulating the performance of TDPS across India to achieve greater food security at the household level.

After South Africa and Brazil, India was the third nation to put a constitutional commitment to the right to food into law (Lindgren, 2022). The Food Security Act is not only a scheme but also an opportunity for India to assume full responsibility for the food safety of its citizens (Karhad, 2014).

In implementing NFSA, technology is being used to ensure transparency, reliability, and efficiency of the food grains procurement, storage, and distribution operations of the TDPS. The use of Aadhaar for the distribution of TPDS rations remains debatable, with critics claiming it is leading to exclusion because of technological failures. ICT has played a significant role in several states where the TPDS has improved its performance, digitizing beneficiary databases, computerizing supply chain management, establishing transparency portals, and establishing online grievance redress mechanisms. These ICT-based reforms are considered highly effective at improving food security in several low-income states like Bihar, Chhattisgarh, and Odisha in preventing food grain leakage from the PDS (Chatterjee, 2014).

Several states in India have made progress in introducing technology in the implementation of the NFSA. For example, Telangana has been at the forefront of leveraging technology to enhance the effectiveness of PDS in terms of introducing the online application of ration cards, computerizing supply chain management, introducing online transactions at FPS, etc (Mishra et al., 2022). Through the implementation of biometric authentication systems, mobile applications, and GPS tracking, Tamil Nadu has improved the targeting of beneficiaries and minimized leakages in food grain distribution (Kumar et al., 2020). Kerala has successfully implemented biometric authentication systems and electronic weighing scales in Fair Price Shops (FPS), along with the computerization of beneficiary databases (Kannan & Raveendran, 2015). Odisha secured the top position in the NFSA Ranking Index of 2022, marking a notable achievement in the modernization of its PDS. Odisha has achieved technological innovation, including the introduction of online monitoring for grain lifting plans across the State (Mishra, 2022). Among all the states of Northeast India Tripura and Sikkim have demonstrated notable progress in NFSA implementation, largely attributed to effective Godown management and Aadhaar seeding initiatives (CAF&PD, 2022).

3. Objectives & Methodology

The study aims to evaluate the effectiveness of technological interventions introduced under NFSA, 2013. It looks at the effectiveness of Aadhar Seeding1, Biometric Authentication2 Systems, Fair Price Shop (Ration Shop) Automation3, Integrated Management of Public Distribution Systems (IMPDS)4, Mobile Applications (Mera Ration App), and Direct Benefit Transfer (DBT)5 programme- in enhancing transparency, accuracy, and accountability of PDS under NFSA, 2013 in the delivery of subsidized food grains. This article also identifies the key challenges hindering the successful adoption and implementation of new technologies under the NFSA of 2013 in Assam. The paper is descriptive. The paper is based on secondary data mainly reports collected from the Government of India (GOI), the Comptroller and Auditor General report (CAG), the Ministry of Consumer Affairs and Public Distribution reports, Concurrent Evaluation of NFSA, GOI reports, Press Information Bureau (PIB) reports, and various research papers, books, journals, newspapers, articles, etc.

4. Use of Technology to Augment Public Policy Delivery

The idea of "e-governance" started to take shape with the development of the internet and has since helped to increase both the effectiveness of internal administration and the accessibility of online services for citizens, and has led to social media advancement which enables ordinary citizens to share more information among themselves and interact actively with governments. ICT has the potential to improve the quality of government and empower citizens. It helps make governments more efficient, effective, transparent, and accountable by reengineering administrative processes, improving public service delivery, and promoting citizen engagement and participation in policy-making processes. By digitizing administrative procedures and providing public information and services to citizens via the Internet, e-government makes governments not only more efficient and effective but also more accountable and transparent (Moon, 2017).

In India, science and technology have been given importance in nation-building since independence, and it has been given immense priority in the field of public policy making. The goal of employing ICT is to make government policies more efficient, effective, and cost-effective. The process of formulating and implementing public policy has taken on the shape of a collaborative effort between governmental organizations, state institutions, and social groupings. The current governance structure is multi-actor and multi-level so digital technologies connect stakeholders and enable evidence-based policy-making. As a result, ITC has become a critical tool in the intricate processes of public policymaking.

4.1 Key Features of NFSA, 2013

NFSA covers up to 75% of the rural and 50% of the urban populations. The households are categorized into two groups one is the poorest of the poor, *Antodaya Anna Yojana* (AAY) households' which are entitled to 35 kg of foodgrains per family per month, whereas the other one is Priority Households (PHH) beneficiaries, who are entitled to 5 kilogrammes per person per month. It is a shift from a welfare-based system to a rights-based system. NFSA, 2013 also provides support for women's and children's nutritional needs under the Integrated Child Development Services (ICDS) and Mid-Day Meal (MDM) programmes, pregnant women, breastfeeding mothers, and children between the ages of six months to fourteen years are entitled to meals that adhere to proposed nutritional content. Pregnant or breastfeeding women are eligible for a maternity bonus worth at least Rs. 6,0006.

Table 1 shows some key TPDS reforms linked with technology that were initiated under NFSA,2013 that have had a tremendous impact on the design and implementation of the NFSA program.

Table 1: Mapping of planning module for induction of technology under NFSA, 2013

Sources of error in TDPS	TPDS Process	Proposed ICT solution by NFSA, 2013	Planning module
Inclusion and exclusion Errors, Ghost card	Identification of Beneficiary	Digitization of beneficiary database, Biometric Identification	Digitization of database
Lack of information to Farmers	Procurement	Use of portal, Mobile application	Computerization of the supply chain
No real-time information on Inventory	Storage	(Radio-frequency identification) RFID-enabled application, Integrated information system	Computerization of the supply chain
Diversion during transit	Transportation Distribution	GPS solution	Computerization of the supply chain

Lack of prior Information to the Beneficiary	Distribution	Information through SMS, Toll-free numbers, Transparency Portal, Online allocation	Transparency portal
Manual recording of transactions at FPS	Distribution	Fair Price Shop (FPS) automation to minimize human intervention	FPS automation electronic Point of Sale (e-PoS)[1]
Lack of attention to Beneficiary complaints	Service Delivery	Grievance redressal mechanism, Toll-Free No	Grievance redressal mechanism

Source: Biswal & Jenamani, 2018

5. Status of Food Security and NFSA Implementation in Assam

As per the World Bank, Assam exhibits a poverty rate surpassing the national average, with certain regions within the state experiencing particularly high levels of poverty. The Planning Commission estimated that in the fiscal year 2011-12, around 25.70 % of Assam's rural population lived below the poverty level. Food security in Assam has been a critical concern, with various socio-economic factors affecting access to adequate and nutritious food for its population.

Baruah & Mahanta (2019) stated that the state faces challenges such as high levels of poverty, inadequate infrastructure, and vulnerability to natural disasters, all of which impact food availability, accessibility, and utilization. Assam's vulnerability to climate change, particularly floods and erosion, poses a significant threat to agricultural productivity and food security highlighting the adverse effects of climate change on crop yields and food production in the State (Saikia et al. 2016).

Government initiatives (such as the NFSA) aim to address food insecurity by providing subsidized food grains to eligible households. However, challenges persist in the effective implementation of these policies in the state. Identifying Below Poverty Line (BPL) households, which poses a significant challenge in Assam due to corruption, is crucial for the success of the entire PDS system.

Assam has been plagued by issues such as leakages, inefficiencies in distribution, targeting errors, and inadequate coverage, leading to gaps in food security coverage under NFSA, 2013 (Barman et al., 2018). There was a problem with poor-quality food grain distribution, smuggling of PDS goods sold on the open market at a higher price, food items delivered to APL households without ration cards,

[1] EPoS is the combination of hardware and software that allows you to accept all types of payments

and food grain delivery delays in Assam (Das, 2017). Therefore, ICT tools provide an opportunity to solve the problem of leakages and target errors as well as the diversion of food grains in PDS by keeping records of the beneficiaries (Gulati and Saini, 2015).

Even after the NFSA implementation in Assam which brought reforms to the existing PDS, the state has neglected many of the reform initiatives mainly the digital initiatives including Aadhar seeding, the adoption of digital payment systems, and the utilization of electronic Point of Sale (e-PoS) machines by FPS, etc. The e-PoS facility is not operational in all areas of Assam. Many FPSs follow a manual records system of beneficiary records of purchasing food grains from FPS (GOI, 2021). There is a need for better targeting mechanisms and improved delivery systems to ensure the efficient distribution of food grains to vulnerable populations (Dutta & Barman 2018).

Addressing food security challenges in Assam requires a holistic approach that includes improving agricultural productivity, enhancing infrastructure, strengthening social safety nets, and leveraging technology to ensure efficient food distribution and accessibility. Moreover, community-based approaches and participatory mechanisms can empower local communities to address food security challenges effectively.

6. Findings and Discussion

6.1 Significance of Technology in Improving the Implementation of NFSA, 2013 in Assam

Technology integration can streamline and automate various processes involved in NFSA implementation, such as beneficiary identification, ration card management, and the distribution of food grains. This efficiency improvement reduces administrative burden, minimizes errors, and ensures timely delivery of subsidized food grains to eligible beneficiaries. Some digitization efforts brought under NFSA, 2013 in TDPS in Assam, have been discussed below:

A) Digitization of Ration Card Database: Digitization of ration card database has proven beneficial in dual aspects. Initially, it enhances transparency through the provision of readily accessible databases (for example status of their ration allocation and distribution, ration card application status) to beneficiaries, government officials, and civil society. Having access to the databases government can easily monitor and manage the food distribution process efficiently. It facilitates the government in implementing supplementary technologies like barcodes and biometric smart cards to eliminate fraudulent or duplicate beneficiaries (PIB, 2015). The digitization procedure, which involves Aadhar seeding (is the process of attaching an Aadhaar holder's unique 12-digit Aadhaar number to their personal identification documents or benefits cards, such as scholarships. Pension ID. MNREGA Job Card, NFSA Ration Card, etc), are critical for various reasons. It helps in authenticating the identity of beneficiaries and ensures that food subsidies reach the intended recipients without

duplication. The state of Assam has achieved nearly 100% success in linking Aadhar with beneficiaries, showcasing a robust model for others to follow. By linking Aadhar with mobile numbers and bank accounts, the state has facilitated greater access to technology for the poor, empowering them with digital tools and services. This linkage not only ensures that the benefits reach the intended recipients but also integrates them into the financial system, thereby promoting financial inclusion. This demonstrates the effective use of technology in public policy, strengthening the NFSA's delivery mechanism and making governance more responsive and inclusive.

Table 2 illustrates the ration card database recorded by the government of Assam. It recorded the total number of beneficiaries, the Aadhaar-seeded RC database, and the Aadhaar-seeded beneficiary database. It highlights the number of ration cards linked with mobile numbers and bank accounts and about female heads of households (HOF) under the NFSA. The count of Silent RCs, which refers to ration cards that have not been used for three months stands at zero.

Table 2: Digitization of Ration Cards in Assam

Category	Total	AAY	PHH
Total Ration Cards	66,45,353	6,73,525	59,71,828
Total Beneficiaries	2,33,10,133	22,04,815	2,11,05,318
Aadhaar Seeded RCs	66,24,260	6,71,387	59,52,873
Aadhaar Seeded Beneficiaries	2,29,44,474	21,61,764	2,07,82,710
Mobile No. Seeded RCs	65,13,971	6,58,936	58,55,035
Bank A/C Seeded RCs	54,33,945	6,00,431	48,33,514
Female HOF (NFSA)	62,20,292	6,26,020	55,94,272
Silent RCs (3 months)	0	0	0

Source: https://nfsa.gov.in/public/nfsadashboard/PublicRCDashboard.aspx[7]

Table 3 presents the district-wise data for Aadhaar-seeded beneficiaries, demonstrating that 33 districts in Assam have successfully achieved Aadhaar seeding for NFSA beneficiaries. Most districts exhibit a high Aadhaar seeding rate, with percentages generally ranging between 94% and 99%. Moreover, Dima Hasao and Majuli, districts where seeding rates exceed 99%, indicate near-complete Aadhaar coverage among beneficiaries. The data was unavailable for the two districts Bajali and Tamulpur in the government records. All total Assam has a total of 35 districts.

Table 3: Aadhaar Seeded Beneficiaries District-Wise

Districts	Total Beneficiaries	Aadhaar Seeded Beneficiaries	AAY	PHH	%
Bajali	No Data	No Data	No Data	No Data	No Data
Baksa	7,26,225	7,16,461	70,240	6,46,221	98. 77%
Barpeta	13,34,764	13,22,600	1,24,051	11,98,549	99.09%
Biswanath	5,79,719	5,65,439	59,524	5,05,915	97.54%
Bongaigaon	5,89,875	5,58,030	54,818	5,03,212	94.61%
Cachar	13,02,217	12,68,571	1,20,341	11,48,230	97.41%
Charaideo	3,26,236	3,22,367	32,462	2,89,905	98.81%
Chirang	4,01,039	3,96,920	44,268	3,52,652	98.97%
Darang	7,27,896	6,97,974	55,641	6,42,333	95.88%
Dhemaji	5,67,055	5,66,420	53,474	5,12,946	99.89%
Dhubri	12,76,601	12,48,560	1,09,889	11,38,671	97.80%
Dibrugarh	8,58,775	8,44,288	79,523	7,64,765	98.31%
Dima Hasao	1,15,842	1,15,788	14,414	1,01,374	99.95%
Goalpara	7,10,314	7,08,794	61,920	6,46,874	99.79%
Golaghat	7,29,660	7,23,458	82,160	6,41,298	99.15%
Hailakandi	5,47,812	5,32,021	45,028	4,86,993	97.12%
Hojai	7,42,870	7,40,046	74,484	6,65,562	99.62%
Jorhat	6,18,527	6,17,437	67,489	5,49,948	99.82%
Kamrup	12,09,865	12,03,704	1,31,197	10,72,507	99.49%
Kamrup Metro	5,35,409	5,33,364	21,386	5,11,978	99.62%
Karbi Anglong	4,25,067	4,23,926	33,316	3,90,610	99.73%
Karimganj	9,41,174	9,31,123	73,629	8,57,494	98.93%
Kokrajhar	7,97,549	7,86,725	75,666	7,11,059	98.64%

Lakhimpur	8,20,713	8,12,676	75,848	7,36,828	99.02%
Majuli	1,50,783	1,50,734	22,246	1,28,488	99.97%
Marigaon	7,84,529	7,74,918	63,429	7,11,489	98.77%
Nagaon	15,38,467	14,97,055	1,43,118	13,53,937	97.31%
Nalbari	6,00,623	5,90,676	72,127	5,18,549	98.34%
Sivasagar	4,95,355	4,93,270	56,003	4,37,267	99.58%
Sonitpur	7,56,569	7,27,243	56,385	6,70,858	96.13%
South Salmara Mancachar	3,63,952	3,61,963	26,114	3,35,849	99.45%
Tamulpur	No Data	No Data	No Data	No Data	No Data
Tinsukia	8,59,928	8,53,116	80,197	7,72,919	99.21%
Udalguri	6,93,629	6,85,822	75,381	6,10,441	98.88%
West Karbi Anglong	1,74,604	1,72,966	6,337	1,66,629	99.06%

Source: https://nfsa.gov.in/public/nfsadashboard/PublicRCDashboard.aspx

*Percentage= (Total Beneficiaries/Aadhaar Seeded Beneficiaries) ×100

B) Real-Time Monitoring or End-to-end Computerisation of TDPS: End-to-end computerization refers to the digitization and automation of the whole process of PDS involved in delivering essential food commodities to eligible beneficiaries. The Department of Food and Public Distribution launched a Plan Scheme for "End-to-End Computerization of TPDS Operations" during the 12th Five Year Plan (2012-2017). Although the online allocation of food grains began in Assam, the computerization of supply chain management was not implemented until 2017 (PIB, 2017). Later, end-to-end computerization was initiated in Assam by selecting three districts- Nagaon, Karbi Anglong, and Kamrup Metropolitan as pilot districts (FPD&CA, 2024). Ration card details are accessible on Assam's transparency portal, and online allocation of food grains has commenced to enhance transparency in the distribution process, extending up to the FPS level; however, all the features of the end-to-end computerization are not fully utilized in the state yet (NFSA, 2023).

C) Integrated Management of PDS (IMPDS) or Portability - 'One Nation One Ration Card': Under NFSA, portability allows individuals who have been issued a ration card or similar entitlement in one state or district to receive their entitled food grains or subsidies while residing in a different state or district. Inter-state portability allows beneficiaries to avail of food subsidies in a different state.

Intra-state portability enables beneficiaries to access their entitlements in a different district or block within the same state. Table 4 illustrates the utilization of the portability facility by NFSA beneficiaries in July 2024 across 33 districts of Assam. However, data for the districts of Bajali and Tamulpur was not available. Portability helps people to get food grain entitlements, particularly for beneficiaries who move across districts or states.

Table 4: District-Wise Portability Abstract for July 2024

District	Total Cards	Availed Cards	Availed Transactions	Availed Port Cards	Availed Port Trans
Bajali	No Data	No Data	No Data	No Data	No Data
Baksa	218,959	204,705	204,723	217	217
Barpeta	365,142	326,854	326,866	965	965
Biswanath	170,572	156,709	156,718	173	173
Bongaigaon	159,637	146,302	146,304	214	214
Cachar	361,948	315,904	315,921	3,026	3,026
Charaideo	99,677	93,613	93,615	112	112
Chirang	114,035	107,744	107,749	192	192
Darrang	198,035	180,060	180,064	249	249
Dhemaji	172,032	163,487	163,869	210	210
Dhubri	323,791	292,555	292,563	415	415
Dibrugarh	270,675	246,829	246,856	728	728
Dima Hasao	33,593	29,157	29,157	183	183
Goalpara	206,723	188,544	188,546	1,013	1,013
Golaghat	241,855	222,215	222,219	459	459
Hailakandi	142,903	127,150	127,160	502	502
Hojai	146,995	136,472	136,601	313	313
Jorhat	210,210	198,832	198,836	203	203

Kamrup	360,560	325,360	325,364	993	993
Kamrup Metro	176,893	142,680	142,684	3,750	3,750
Karbi Anglong	119,988	109,658	109,660	841	841
Karimganj	248,271	217,480	217,501	906	906
Kokrajhar	214,321	199,841	199,844	551	551
Lakhimpur	241,591	225,781	225,797	399	399
Majuli	44,370	42,196	42,196	46	46
Marigaon	229,585	203,619	203,621	814	814
Nagaon	350,068	320,767	320,802	1,478	1,478
Nalbari	178,812	163,058	163,059	176	176
Sibsagar	160,069	150,410	150,413	104	104
Sonitpur	243,580	217,801	217,822	1,490	1,490
South Salmara Mancachar	86,593	76,618	76,618	147	147
Tamulpur	No Data	No Data	No Data	No Data	No Data
Tinsukia	278,047	256,454	256,472	734	734
Udalguri	202,568	186,349	186,354	830	830
West Karbi Anglong	48,965	42,951	42,955	291	291
Total	**6,621,063**	**6,018,155**	**6,018,929**	**22,724**	**22,724**

Source: https://epos.assam.gov.in/Portability_Interface.jsp[8]

The implementation of ONORC began in August 2019. Under the 'ONORC' initiative, Ration card portability was introduced to enhance flexibility and convenience for beneficiaries, particularly migrant workers, who frequently move due to various reasons such as employment opportunities or personal factors. This allows eligible households to access food grains from any FPS across the country

through biometric identification. Assam joined the project in June 2022, indicating a delayed implementation of India's ambitious digital program in the state (Northeast Today, 2022). However, the State is actively working on improving the system and addressing challenges such as card seeding and inter-district transfers. Table 5 shows the application of ONORC in Assam which indicates (in and out) card transactions and transfers in June and July 2024 in the state. ONORC is meant to facilitate greater accessibility and convenience for beneficiaries, particularly those who move across districts or states.

Although Assam has a high incidence of out-migration, data on the usage of ONORC was limited. As per the Government report 2023, the implementation of ONORC has been carried out in the state; however, its utilisation in FPS by beneficiaries is limited, mainly due to the lack of awareness among the beneficiaries. Hence, ONORC has not been utilized well in the State.

Table 5: ONORC Status for June & July 2024

Month	Direction	Cards	Transfers
June 2024	In	13	13
	Out	0	0
July 2024	In	30	31
	Out	526	553

Source: https://epos.assam.gov.in/impds_interface.jsp[9]

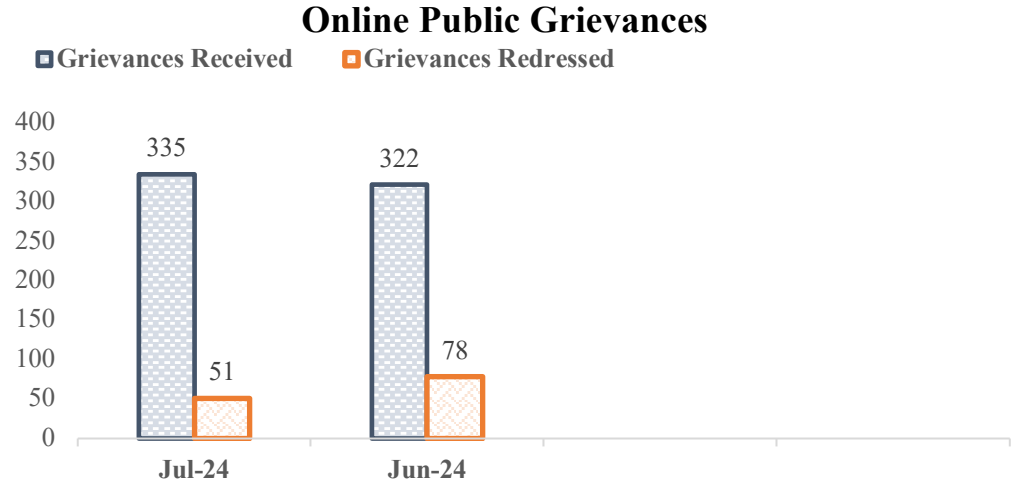
D) Fair Price Shop (FPS) Automation: FPS automation modernizes and optimizes the processes involved in food grain distribution by transitioning from manual record-keeping to digital systems. This shift reduces paperwork, errors, and administrative workload. It enhances the management of beneficiary data, entitlements, and stock levels, leading to more efficient FPS operations. FPSs in Assam have implemented electrical weighing machines, all of which are operational. This ensures accuracy in measuring food grain quantities, enhancing transparency and fairness in distribution. The ePOS system verifies beneficiary data through biometric or Aadhar authentication, ensuring that only legitimate cardholders or beneficiaries can access PDS benefits. Prior to this reform, the lack of such a mechanism enabled corrupt officials and employees within the Food and Civil Supplies Department to form networks with FPS owners, facilitating the diversion of PDS foodgrains to ineligible individuals. This corruption also led to the pilferage of PDS benefits, with wholesale dealers selling subsidized rice, wheat, or pulses at market prices, thereby depriving eligible cardholders of their entitlements (Sentinel Assam, 2024).

Concurrent evaluation of NFSA report 2023 highlighted that the Government of Assam has introduced e-POS facilities in FPSs, marking a significant step towards modernizing transaction processes (GOI, 2023). However, beneficiaries continue to make cash payments at FPSs because they do not have an Aadhar Card, which disqualifies them from obtaining a smart ration card for e-POS transactions. Beneficiaries who have Aadhar the implementation of biometric authentication has

been largely successful, with over 90% of attempts resulting in successful authentication in e-POS transactions. To buy the food grains beneficiaries typically take less than a minute to complete the authentication process when a data connection is available for the transaction through the e-POS machine. However, in some cases, FPSs have identified authentication failures primarily due to issues such as poor fingerprint quality, slow internet, and battery problems in e-POS machines. Also, CCTV installation has not been implemented across FPSs according to the act guidelines (GOI, 2023).

E) Grievance Redressal (GR): The Assam government has established grievance redress mechanisms to facilitate easier access for PDS beneficiaries, including toll-free helplines for lodging and tracking complaints regarding PDS operations. The PDS Public Grievance Redressal Cell-Call Center is a physical facility that operates from 9 AM to 6 PM. Anyone can call the PDS Public Grievance Redressal Cell-Call Center at 1967 (BSNL) or 1800-345-3611 (toll-free number) to submit their complaints. In Assam, although a grievance redressal mechanism exists, many beneficiaries are unaware of it. While a user-friendly online portal (www.assam.grams.nic.in) for grievance redressal was found, very few complaints were registered through it. Despite the state government maintaining a web portal for grievance redressal, digital complaints are minimal, with most people preferring offline channels to lodge their grievances (GOI, 2023). Figure 1 shows the limited number of grievances received and disposed of in June and July 2024 via online mode out of a total of 2,33,10,133 NFSA beneficiaries.

Figure 1: Online Public Grievances Record



Source: https://assam.grams.nic.in/Entrygrv.aspx[10]

F) Direct Benefit Transfer (DBT): The DBT system is a significant digital initiative by the government aimed at reforming the PDS under the NFSA. Unlike traditional methods where beneficiaries receive subsidized food grains, DBT provides cash transfers directly to their bank accounts. This approach encourages a diverse and nutritious consumption pattern, curbs leakages in

the system, and fosters financial inclusion. Beneficiaries have the flexibility to purchase food grains of their choice from the open market (Department of Food & Public Distribution, 2024). While the DBT program has been initiated in Union Territories (UTs)-Chandigarh, Dadra, and Nagar Haveli (urban areas), and Puducherry, it has not been implemented in the Northeastern region as well as in the other states of India (NFSA, 2024). The DBT experiment aims to minimize physical movement, empower beneficiaries in selecting their consumption preferences, enhance nutritional diversity, reduce leakages, improve targeting, and promote financial inclusion.

G) Mobile Application: To reach the intended beneficiaries "Mera Ration App" a mobile application has been developed by the Indian government to streamline the process of accessing ration-related services. It was launched by the Ministry of Consumer Affairs, Food, and Public Distribution. The "Mera Ration App" supports multiple Indian languages but the Assamese language has not been introduced yet. To make it more user-friendly the local language interface is much more relevant it will help the beneficiaries a lot to know about their entitlements.

In Assam, the use of technology for NFSA implementation is growing. But the problem lies in the rural parts, where internet connectivity is not so common. In Assam, an online system has been implemented for applying for ration cards, yet slow internet connectivity in rural areas poses challenges to its widespread use. The SMS alert provision in the NFSA is designed to notify beneficiaries about the availability and distribution of their entitled food but is also not implemented in the state (GOI, 2023).

Moreover, FPS automation measures have advanced with the introduction of e-POS capabilities, but cash payments continue to prevail, and CCTV installation has yet to be completed, indicating gaps in technological integration and compliance. The low use of online grievance redressal portals emphasizes the significance of boosting awareness and improving digital literacy among beneficiaries. Another important provision of NFSA the DBT programme, should be incorporated as per NFSA guidelines to help the beneficiaries with cash assistance instead of food grains. Therefore, ongoing efforts must focus on addressing technological gaps and ensuring seamless integration of digital innovations to optimize the effectiveness of NFSA implementation in Assam.

6.2 The Major Challenges in Technology Adoption in Assam

In Assam, the adoption of technology under the NFSA, 2013 faces several key challenges. According to the World Bank, Assam faces infrastructural deficiencies that hinder technological advancements and access to digital services (World Bank, 2018). Rural areas in Assam suffer from poor such as telecommunications and electricity infrastructure. Private companies tend to invest in profitable urban locations, leaving rural regions neglected. Additionally, low digital literacy and awareness in these rural areas prevent people from adopting modern technologies (Rahman & Zaman,

2018). Therefore, getting NFSA benefits many beneficiaries remain unaware of the technological solutions due to a lack of understanding and empowerment regarding modern technologies.

Financial constraints also limit the ability of FPS in Assam to invest in technology such as the purchase of e-POS machines for digital payment. Funds are required to acquire, install, and train personnel to operate such equipment, posing a challenge to the effective distribution of food grains to beneficiaries. Slow internet services in the hilly areas of Assam result hampers the implementation of end-to-end computerization of TDPS and GPS monitoring of good grain movements across the state, preventing real-time data monitoring and leading to misuse of food grains and leakages. These problems demonstrate the complex backdrop for technology adoption under the NFSA in Assam.

6.3 Recommendations

The augmentation of technology in the implementation of the NFSA of 2013 is a critical aspect of modernizing the welfare delivery system. Innovative technological solutions can overcome implementation challenges and contribute to ensuring food security for vulnerable populations. Introducing new initiatives such as data analysis, assessing FPS viability, and establishing dashboards for FPS data and reports, alongside social audits, and oversight mechanisms under NFSA, can greatly enhance the efficiency of the PDS.

The major recommendations of the study are:

1. ***Convergence of various Agencies to Leverage Technology:*** Collaboration between the Department of Food and Public Distribution and the Department of Telecom (DoT) is necessary in Assam to address low internet connectivity issues. Installing optical cables and implementing 5G services can accelerate digitalization efforts under NFSA.
2. ***Steps to increase FPS Income:*** Encouraging FPS owners in Assam to operate grocery shops alongside FPS can enhance their viability. This enables FPSs to cover expenses such as internet and electricity bills, facilitate online distribution processes, and use electronic machines for food grain distribution.
3. ***Alternative means for Service Delivery:*** In areas of Assam with poor data access, alternative arrangements such as Data Cards/Mobile hotspots should be implemented to ensure internet connectivity and facilitate Aadhaar-based biometric transactions at FPSs.
4. ***Regular Camps for Awareness Generation:*** Awareness campaigns are crucial in Assam to promote the portability facility and familiarize beneficiaries with technology usage. Launching SMS services in local languages to inform beneficiaries about food grain availability and release dates can enhance awareness, aligning with NFSA, 2013 norms.
5. ***Monitoring of the Scheme:*** Regular monitoring is essential in Assam to assess the impact of NFSA and identify challenges in technology adoption. Monitoring provides valuable insights into the effectiveness of NFSA in addressing food security issues in the state[11].

6. ***Create Mobile Applications:*** Developing mobile applications in the local language of Assam will allow NFSA beneficiaries to access information about their entitlements, check ration card status, and file grievances conveniently. It can facilitate direct communication between recipients and authorities, enhancing transparency and accountability in the distribution system.

7. Conclusion

Assam, like the rest of the Northeast region, is characterized by vulnerability, marginalization, inaccessibility, cultural diversity, ethnicity, and rich biodiversity. The NFSA, 2013, has achieved tremendous progress in enhancing technology in the region. ICT introduced under the act plays a pivotal role in resolving inclusion and exclusion errors, detecting multiple or ghost cards, maintaining a comprehensive database of entitlements and beneficiaries, and ensuring the distribution of food grains through biometric identification. To make NFSA successful issues of the digital divide need to be addressed. To bridge the digital gap effectively, three crucial elements must be emphasized: entrepreneurship, government policies that promote equity, and ground-level programs with active local community involvement. Partnerships between local bodies such as Panchayats, Autonomous District Councils (ADCs), Non-Governmental Organizations (NGOs), and cooperative societies are essential for the successful implementation of NFSA, 2013 and crucial for monitoring the policy's ground-level execution.

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Notes

[1] Aadhaar seeding is the process of attaching an Aadhaar holder's unique 12-digit Aadhaar number to their personal identification documents or benefits cards, such as scholarships. Pension ID. MNREGA Job Card, NFSA Ration Card.

[2] Biometric authentication is a cybersecurity procedure that confirms a user's identification by utilizing unique biological characteristics such as fingerprints, voices, retinas, and facial features.

[3] FPS Automation refers to electronic transactions at the FPS level. This automation helps record and transmit transactions at the FPS.

[4] Under IMPDS eligible ration card beneficiaries covered by NFSA will be able to lift their entitled foodgrains from any FPS of their choice anywhere in the country by using their biometric or Aadhaar authentication on an electronic Point of Sale (ePoS) device.
[5] Through DBT, benefits, and subsidies will be transferred directly to citizens living below the poverty line.

[6] National Food Security Act, 2013 (https://nfsa.gov.in/portal/nfsa-act).
[7] National Food Security Act. 2013 (https://nfsa.gov.in/public/nfsadashboard/PublicRCDashboard.aspx)

[8] EPOS 2024. https://epos.assam.gov.in/Portability_Interface.jsp

[9] ONRC 2024. (https://epos.assam.gov.in/impds_interface.jsp)

[10] GRAMS 2024. (https://assam.grams.nic.in/Entrygrv.aspx)

[11] Though there are mechanisms for monitoring of the scheme and physical inspection of the ration shops by the district food inspector, its efficacy can be called to question. Vigilance committees are constituted at the village level as per NFSA rules, but they are mostly dysfunctional, according the primary survey conducted by the authors.

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IPPR

Mobile manufacturing path for India: Lessons from other Asian countries

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Abstract

For almost two decades now Government of India has tried out numerous policies for establishing mobile manufacturing in the country. Though mobile production facilities started their operations in India in 2005, studies have shown that it is only low value assembly that is carried out in the country. In this paper, we infer a few policy lessons for India from the experiences of four Asian countries – South Korea, Taiwan, China, and Vietnam – that have walked down this path. We argue that for India to attain its goal, increasing public investment in mobile technology research will help. Our paper suggests that government should incentivise local firms to establish linkages with mobile manufacturing multinational firms. To capture more value, domestic firms that manufacture mobiles need to focus on R&D, marketing and branding activities.

Keywords: Mobile manufacturing, Industrial policy, India, China, Vietnam, South Korea

JEL Classification: L96, N65, O38, O25, O53

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1. Introduction

Being the second largest populated country in the world, it is natural that India is among the largest mobile markets globally (ICEA, 2019). Since there is very little electronics manufacturing in the country, a booming mobile market implies huge imports of electronic components – for example, the import share of electronic goods was 12% in 2021-22. Thus, electronics and in particular mobile phone manufacturing provides an opportunity to increase the manufacturing activity in the country.

To this end the Indian government has come up with numerous policies for the sector, which are reflective of the industrial policy pursued by the government. As a part of the 'Make in India' (MiI) policy for mobile manufacturing, in 2015-16, the Indian government implemented the Phased Manufacturing Programme (PMP). It can be argued that production or assembly of mobile phones in India zoomed up due to the PMP, from US $8.2 billion in 2015-16 to US$ 25.9 billion in 2018-19; imports have decreased, and exports of mobile phones are up. However, imports of key components used in the production of mobile phones have also increased during this period. This is because of the strategies followed by global mobile phone firms where they carry out their core activities in their home countries (Dedrick and Kraemer, 2017).

Another recent policy measure is the Production Linked Incentive Scheme (PLI). Using PLI, the government wants to create capacity and an ecosystem for mobile manufacturing in the country. It is an open question as to whether the policy measures announced till now by the Indian government will help it in developing the mobile phone manufacturing sector.

To answer this question, as well as to outline a few choices India can take in this sector, we first explain the evolution of mobile manufacturing along with the different paths taken by various countries that lead in the manufacturing of mobiles (section 2). We then focus on the policies implemented by the Indian government, and the impact of these policies (section 3). Section 4 of the paper concludes with some observations and a few choices that India can make for the development of this sector. At this stage, it may be appropriate to point out that the aim of this paper is not to lay out a detailed road map, but rather to point out a few options that may be available for India, given the policies it has implemented so far.

2 International mobile manufacturing

Mobile phone production, like many other industries, shifted from advanced industrial countries to developing economies. Lee and Gereffi (2013) argue that between 2001 to 2011, the shifting of the production process as well as rise of global value chains (GVC) resulted in a few countries consolidating their share in global exports of mobile phones, which implied consolidation of production in those countries. For example, in 2001, developed countries such as Germany, the UK, South Korea, the US, and Finland dominated mobile phone exports. By 2011, however, 61% of the total exports came from China, South Korea, and Hong Kong (Lee and Gereffi, 2013).

The dominant position of these countries in mobile phone exports has continued ever since. Simultaneously, in addition to shift in production, the mobile phone industry also witnessed shift in composition of its users. People in low- or middle-income countries took to using mobile phones, which implied a drop in prices and tremendous market expansion. Policies of individual countries, especially on the production side, also helped in hastening this process; in particular, policies adopted by China, Taiwan, and South Korea have made an impact on the global production of mobile phones. Recently, even Vietnam has emerged a mobile phone manufacturing destination.

2.1 South Korean manufacturing

Hobday (1995) notes that, in the late 1980s, much of the South Korean electronic output was low-quality and low-cost products. In their quest to move towards telecommunications, South Korean firms a) increased their R&D spending, focusing primarily on improving manufacturing technology and market development; b) acquired high-technology firms in other countries; and c) formed technology partnerships with leading foreign companies.

These firms' research hardly focussed on producing new products or knowledge additions through basic research in the field of electronics. Human capabilities in electronics and telecommunication in South Korea was supported by the 'time division exchange national R&D project' that lasted from 1979 till 1991 (Park, 2013). In the early 1990s, when South Korea wanted to enter mobile manufacturing, leading US and European firms were reluctant in transferring technology. To get a foothold in the industry, Korea avoided adopting the popular time division multiple access (TDMA) technologies and embraced code division multiple access (CDMA) technology (Lee et al 2016).

More than 50% of the money made available for CDMA development came from government, with the remaining coming from manufacturers and telecom service providers. A government-run electronics and telecommunications research institute (ETRI), along with Qualcomm, was mainly responsible for developing the CDMA system. Manufacturers were in charge of commercializing the CDMA system, while the service providers had to buy these systems to set up the service infrastructure. An R&D community consisting of all these stakeholders was instrumental in the successful fruition of the development effort (Park, 2013).

The government protected local producers[1] in the domestic market from competition with global brands[2] by awarding CDMA-only mobile service licenses. An innovative way of financing ensured that the cost of developing domestic capabilities was shared in some parts by the mobile service operators as well as final consumers. Park (2013) notes that this first-in-the-world CDMA system utilized spectrum-hopping technology to amplify capacity.

By September 1999, Korea had exported 90 billion won worth of systems, and 1.5 trillion won worth of mobile handsets. Thus, a secured home market not only helped South Korean firms focus on CDMA phones exports[3] to a wide range of markets, but also allowed them to build up domestic capabilities, because of which they were later able to quickly learn and assimilate GSM technology [a].

Lee *et al* (2016) note that export orientation led to a globalised production strategy for South Korea's leading firms; for example, in 2011, more than three-quarters of phones were produced in China and Vietnam. Leading firms also invested in R&D capabilities abroad, which helped them assimilate advanced technology and market trends. Further, leading South Korean producers are also highly vertically integrated. Lee *et al* (2016) note that in 2011, LG outsourced only 13% of its mobile phone production, and Samsung produced its mobile phones in-house[4]. Samsung and LG source many of the key components from their related companies[b] (Lee *et al*, 2016).

2.2 Taiwanese manufacturing

Taiwanese firms entered mobile manufacturing in the 1990s, primarily as suppliers – many started as producers of cases for keypads. Later, some of these firms started assembling mobile phones according to the designs and specifications of buyers. With time, some firms accumulated capabilities in scale and technology to provide electronic manufacturing service (EMS). These firms specialised in supply chain management and large-scale manufacturing for global brands. A few others developed product design capability, becoming original design manufacturers (ODMs) to capture the design to assembly value chain.

In the early 2000s, when the focus was on outsourcing, these firms helped the growth in Taiwan's exports of mobile phones. The remaining firms in the Taiwan ecosystem relied on their strong R&D competency to focus on a variety of high value-added components. Thus, Taiwan rose successfully as a specialized supply base, while South Korea was successful in nurturing global brands (Lee *et al*, 2016).

2.3 Chinese manufacturing

In its aim to enter mobile manufacturing, China has followed multiple paths (Lee *et al* 2016).

First, in the late 1980s, for multinational corporations (MNC), the Chinese government linked domestic market access and technology transfer, with the hope for spillover effects (Zhao *et al*, 2007).

Second, the Chinese government used industrial policy to shield and nurture domestic firms (Imai & Shiu, 2007; Zhao *et al*, 2007). Though imports of finished handsets were strictly controlled, until the late 1990s mobile phone production was dominated by foreign firms, which set up joint ventures with state-owned telecommunication equipment makers. As the literature would predict, these joint ventures assembled components, because of which local partners did not acquire much technological capability. However, by 1999, licenses were made mandatory for the production, expansion of production, and marketing of mobiles. For foreign joint ventures regulations such as minimum export ratio and local content requirements were imposed (Imai & Shiu, 2007).

Since the chances of getting a license were slim, many Taiwanese ODMs joined forces with local firms that already had obtained a license. These policy measures helped China become an important mobile phone manufacturing destination; Brandt & Thun (2011) note that between 1998 and 2009, China increased its share from 2% of global production to approximately 50%, and that most of this

production was for exports. Competition and success[5] in the local market helped local firms to emerge successful in international markets.

Third, to cater to its huge domestic market, the Chinese government worked with domestic and foreign firms to develop an indigenous 3G standard[6], which was then licensed to the largest mobile network operator (China Mobile). Brandt and Thun (2011) emphasize that the domestic standard forced MNCs to adapt. If firms wanted to do business with China Mobile, they were forced to develop entirely new products, rather than introduce global products with slight changes in the user interface.

The benefit of this adaptation was that much of the design and engineering work that was related to the standard was done in China, both within internal R&D units and external independent design houses (IDHs), which helped establish an ecosystem in China. Lee *et al*(2016) point out that existence of a huge domestic market increased the adoption of home-grown standards, which incentivised MNCs to come up with handsets for these standards. Finally, it is important to infer that with the investments to build its own standard, China also built up its capability to absorb and assimilate various technologies[7].

2.4 Vietnamese manufacturing

Recently, Vietnam has integrated itself into the mobile phones GVC. The World Bank argues that it is a success (WDR, 2020). Vietnamese policy primarily included offering huge financial and tax incentives to firms, because of which renowned global manufacturers have set up facilities in Vietnam. As per UN Comtrade data, Vietnam's exports of mobiles have zoomed from US$ 1.6 billion in 2010 to US $ 33.6 billion in 2021. We review the Vietnamese experience in detail in section 4.

To summarize, all the four countries mentioned above have made a mark for themselves in the mobile manufacturing segment. South Korea and Taiwan have built capabilities which make them a formidable participant in the ecosystem. As we will discuss later, China and Vietnam are yet to build these capabilities. If India is indeed serious about being a global player in this segment, then focusing on capabilities is critical. In the next section, we summarize the production and trade policies in India that are relevant for building capability in mobile manufacturing.

3 Indian Policies for Mobile phone manufacturing and its impact

3.1 Production policies pre-2012

The policy framework that was followed in independent India for electronics manufacturing emphasized self-reliance. High tariffs and quantitative restrictions ensured some local hardware production, which got a further boost in the early 1980s, when policy allowed for duty-free import of capital goods and lower duty on components. Financial benefits as well as relaxations of labour and environmental laws were used to encourage local production.

Francis (2016) points out that policy did not link local hardware production with the growth in software exports[8], thereby losing an opportunity for capability development. This linking could have increased the productivity of existing hardware manufacturers. The government also did not build on the R&D capabilities India had built in developing digital switching equipment (Mani, 2005). Simultaneously, lack of capability development policies in the consumer electronics industry was apparent, and cost us dearly (Francis, 2016).

3.2 Trade policies

India joined the Information Technology Agreement (ITA-1) in 1997, when as per Ernst (2014) its electronics sector was initializing. As per ITA-1, each signatory was bound to eliminate customs duties, other duties, and charges of any kind on the trade of information technology products. Ernst (2014) highlights that India's entry into ITA-1 not only drastically reduced chances of improving domestic capabilities, but also discouraged investors from scaling such capabilities in India[c]. Excessive speed in the implementation of tariff reductions and the resultant jump in imports decimated local production (Francis, 2018). Export and import figures from headphones and ear phones sub-segment[9] of the telecommunications segment makes this point amply clear.

In addition, the ASEAN, Japan, and South Korea free trade agreements (FTAs) opened tariff lines that were not covered in ITA-1, which added on to the impact. Policymakers hoped that India's integration into electronic GVCs would be expedited by these FTAs, which did not happen (Francis, 2018). Indian experience with its liberal foreign direct investment (FDI) regime since 1991 in the electronics sector confirms the literature's expectations, i.e., large MNCs set up only final assembly plants, increasing import dependence without creating domestic backward linkages[d] (Ernst, 2014; Saripalle, 2015, Rajakumar, 2014; Verma, 2015, Francis, 2016).

Table 1: Export and import of Headphones Earphones and Combined Microphone or Speaker Sets (HS85183000) in US $ million

Fiscal Year	Exports	Imports	E-I
1997	0.090	0.600	-0.510
1998	0.140	1.920	-1.780
1999	0.330	1.920	-1.590
2000	1.040	1.980	-0.940
2001	0.510	2.680	-2.170
2002	0.570	4.560	-3.990
2003	0.420	10.000	-9.580
2004	0.140	8.580	-8.440
2005	0.090	11.460	-11.370
2006	0.140	15.110	-14.970
2007	0.130	22.710	-22.580
2008	0.350	33.000	-32.650
2009	0.570	89.940	-89.370
2010	4.210	60.470	-56.260
2011	0.120	78.990	-78.870
2012	0.770	191.950	-191.180
2013	0.460	218.240	-217.780
2014	0.770	172.410	-171.640
2015	1.610	117.250	-115.640
2016	1.180	137.830	-136.650
2017	1.690	192.080	-190.390
2018	2.850	242.630	-239.780
2019	9.880	282.490	-272.610

Note: 1997 implies April 96- March 97.

Source: CEIC database

3.3 Production policies post 2012

The decimation of local hardware production in electronics prompted Indian policy makers to come up with the National Policy on Electronics (NPE) 2012.

- One of the policy initiatives in this regard has been the Modified Special Incentive Package scheme (M-SIPS), under which mobile units enjoyed capex benefits.
- In addition, 100% FDI is permitted for the mobile manufacturing ecosystem. Export incentives were made available under the Merchandise Export from India Scheme (MEIS)[10], and duty-free imports of specified capital goods were permitted.

- Units in special economic zones (SEZ) can avail tax benefits, both at the central and state/provincial level.
- Provincial or state governments have also announced competitive incentives on taxes, land, and inputs.
- The PMP[11] - policy that discourages imports by imposing higher tariffs - implemented by the central government encourages local manufacture or assembly of low-value (followed by higher-value) components (Table 2).

Table 2: PMP – mobile phones

Year	Sub-Assembly	Duty Structure under PMP
2016-17	Charger/ Adapter, Battery Pack, Wired Headset	15 % (Implemented)
2017-18	Mechanics, Die Cut Parts, Microphone and Receiver, Key Pad, USB Cable	15 % (Implemented)
2018-19	Printed Circuit Board Assembly (PCBA), Camera Module, Connectors	10% (Implemented)
2019-20	Display Assembly, Touch Panel/ Cover Glass Assembly, Vibrator Motor / Ringer	Likely to be deferred

Source: Ministry of Electronics and Information Technology, Government of India; Mani (2019)

In April 2020, mobile production was among the first sectors for which the government implemented PLI, another incentive-based scheme, on incremental sales over FY20 for a period of five years. Firms desiring the incentive had to apply for the PLI scheme, and a few domestic and foreign firms were selected.

Incentive disbursement under PLI is subject to meeting incremental investment thresholds and incremental mobile phone sales targets; foreign and domestic mobile firms have different thresholds. For example, incremental investments over four years for domestic and foreign firms are Rs. 200 crores and Rs. 1,000 crores respectively. Similarly, the thresholds for incremental mobile sales vary for domestic and foreign firms. Incentives under PLI were supposed to be applicable from August 2020. To summarize, for mobile manufacturing, in addition to the general central and state-level industrial incentives, we have the PMP and PLI that are applicable as well.

3.4 Indian mobile manufacturing scenario

Mobile phone production in India began in 2005, when there were a series of investments in manufacturing facilities by OEMs (LG, Nokia, and Samsung) and EMS (Elcoteq and Flexotronics) firms. Table 3 presents the production, imports and exports of mobile phones, and imports of parts of mobile phones over the years.

Table 3: Production, Imports and Exports of Mobile Phones and its parts in US $billion

Year	Production (MP)	Imports (MP)	Exports (MP)	Imports of PCB	Imports of Other parts
2009-10	6.5	3.23	1.28	0.138	1.842
2010-11	7.8	5.47	2.62	0.138	2.961
2011-12	8.5	5.82	2.73	0.128	2.555
2012-13	8.5	4.75	2.66	0.122	2.783
2013-14	4.4	5.93	1.95	0.105	2.568
2014-15	3.1	7.95	0.26	0.197	2.642
2015-16	8.2	6.06	0.22	0.542	4.497
2016-17	13.4	3.79	0.17	1.181	6.259
2017-18	20.5	3.54	0.21	4.856	6.707
2018-19	24.3	1.62	1.61	2.121	6.592
2019-20	31.7	1.04	3.84	0.699	7.225
2020-21	30	2.23	3.07	0.537	6.445
2021-22	38	1.49	4.58	0.533	7.401
2022-23	--**	0.033	0.042*	--	--

MP: Mobile phones; PCB: Printed circuit boards; Other parts: Mobile phone parts; NA: Not available.

*- Ikdhvaj & ICEA (2023) puts this at US $ 11.1 billion

**- Ikdhvaj & ICEA (2023) puts this at US $ 44 billion.

Source: Ministry of Commerce and Industry, Government of India for imports and exports; various annual reports of Ministry of Electronics & Information Technology, Government of India for production.

Wilde & Haan (2006) observe that, in 2005, companies imported a majority of their raw materials (75-90% of total inputs), and firms were engaged largely in labour-intensive, low-technology assembly work, with very little value addition. The closing of the Nokia facility at Sriperumbudur led to a drastic decline in production and surge in imports of mobile phones in 2014-15.

There has been some impact of the NPE combined with PMP policy, as production of mobile phones in the country has increased, imports of mobile phones have reduced, and exports are on the rise[12]. PMP implementation has also ensured that electronic components are imported and used for assembling mobile phones in the country. For PCB imports, the drastic increase in FY 18, drop in FY 19, and further steep drop in FY 20 can be attributed to the PMP for PCB that came into effect in FY 19.

Imports of other parts of mobile phones continue to increase. Increasing production in the past few years has been due to investments in final assembling facilities for mobile phones. These investments have been primarily due to the establishment of facilities by foreign firms, whose market share has also increased commensurately during this period. For example, in the second quarter of 2018, foreign brands such as Xiaomi, Samsung, Vivo, and Oppo together had a market share of 73.8%

of the Indian smartphone market (ICEA, 2019). To offset the exchange rate risk, especially when the rupee becomes weak[13], and take advantage of MiI and PMP policies to consolidate their position in the country, these brands have been investing in manufacturing or assembling facilities in India.

The increasing market share of foreign brands has been at the expense of Indian brands, which dominated the Indian market till FY 15. Indian mobile firms, which generally operate at a much lower scale than foreign firms, now account for a very low share of the Indian market. Additionally, the huge imports of PCBs and other mobile parts point to the lack of a component ecosystem in the country. Most of the components continue to be imported, despite the rise in basic customs duty[14] after implementation of the PMP.

Dependence on imported raw materials

After the macro picture, it may be useful to look at firm level data. For this, we pick up units from National Industrial Classification (NIC) code 26305 [Manufacture of pagers, cellular phones and other mobile communication equipment] that were reported in the Annual Survey of Industries[15] (ASI), published by the Ministry of Statistics and Programme Implementation, Government of India (2016-17 and 2017-18 data). Firms at the five-digit classification level buy inputs from domestic as well as foreign sources.

Table 4 shows the details for 2016-17 and 2017-18 for mobile producing units only. To make the analysis size independent, we present the ratio of raw materials in the total cost of production.

Table 4: NIC 26305 units – raw materials share of total cost of production

2016-17			2017-18		
Unit	Local	Import	Unit	Local	Import
1	0.003	0.953	1	0.023	0.936
2	0.949	--	2	0.922	--
4	0.002	0.946	3	0.112	0.845
6	0.032	0.908	5	0.110	0.866
7	0.013	0.937	10	0.058	0.426
9	0.036	0.011	11	0.931	--
12	0.003	0.969	12	0.002	0.972
14	0.009	0.813	13	0.003	0.864
			14	0.062	0.908

Source: ASI data for NIC code 26305 for 2016-17 & 2017-18.

For 2016-17 and 2017-18, we find that most of the units rely on imported inputs. Poring through the details of imports, one finds that both for 2016-17 and 2017-18, electronic components dominate. Thus, electronic component manufacturing for mobile production in India is negligible.

(Among locally sourced non-electronic inputs, bulk of the sourcing is for cardboard boxes and packing material!)

This is in line with empirical evidence that MNCs locate core activities in their home countries and set up low-value-add assembly plants in growing markets (Table 5). Lee and Jung (2015) highlight that, though Samsung relocated some segments of value chain abroad, the higher-value segments such as R&D and marketing remained in Korea. Dedrick and Kraemer (2017) find that the share of assembly cost in the total cost of a mobile[16] is among the least. India's experience with the Nokia assembly plant near Chennai has not only demonstrated the fickleness but also shallowness of such assembly investments.

Table 5: Location of activities in the global value chain of the smartphone segment

Activity	R&D, Design, Sourcing	Development &Engg	Manufacture of key components (production)	Final Assembly (production)
Apple	US	US/Taiwan	US/Japan/Korea/ Taiwan/China	China*, India*
Samsung	Korea	Korea	Korea/Japan/US/ China	Korea, Vietnam, China, India, Brazil, Indonesia
Huawei	China	China	China/Korea	China, India

* as of 2017

Source: Dedrick & Kraemer (2017)

Competition from local brands

Domestic firms have been an important part of the mobile phone manufacturing ecosystem in the country. In the early part of the decade, in a fast-growing market, Indian phone makers competed well with foreign firms. Leading the charge was Micromax (Bhagwati Products Ltd.), in some sense the poster boy of the Indian handset industry. Ding and Pan (2011) note that 200 local companies in India, including local brands such as Micromax and Lava, used ODM firms from the Shanzhai system[17] in China to transform from distributors to brand owners. Table 6 below uses available data to substantiate this statement.

As the PMP was implemented, dependence on imported raw materials for Micromax increased from 26% in FY14 to almost 83% in FY17. This is a hint that, before PMP, this firm imported mobile phones in semi-knocked-down kits format and assembled them here; while after PMP it has been importing in completely-knocked-down format. For Lava, as the PMP has been implemented, they have moved from importing finished goods to importing raw materials. It needs to be pointed out that product design for Lava is done from China[18].

Table 6: Performance of selected domestic firms in Rs. million

	Bhagwati Products Ltd.			Lava International Ltd.		
Year	Sales	IRM	IFG	Sales	IRM	IFG
2013-14	3613.3	937.3	--	26992	--	20492.2
2014-15	18290.1	10563.2	--	44881.9	--	35458.4
2015-16	47634	38410.3	--	48120.4	35465.2	--
2016-17	21674.4	17943.6	--	36279.6	23299.7	--
2017-18	21141.6	--	--	32446.2	20831.4	--
2018-19	8534.5	--	3354.9	28913	18186.1	--
2019-20	4528.6	--	3297.5	17899.2	11013.4	--
2020-21	9963.7	--	7719.8	15924.8	--	--
2021-22	13304.9	--	7739	18109.6	--	--
2022-23	9229	--	4992.7	--	--	--

Note: IRM – import of raw materials, IFG – import of finished goods

Source: Prowess, Centre for Monitoring Indian Economy

No wonder that, from a peak of over 45% in 2014, the share of Indian brands fell below 10% in 2018. This was principally because Chinese firms not only outdid Indian firms in the price game, but also turned the competitive dynamics at the lower end of the handset market from price to value. From being fringe players offering inexpensive phones to price-sensitive consumers, Chinese handset firms have risen to corner an unprecedented 60% share of the smartphone market in 2018.

Table 7 shows the recent financial performance of one Chinese firm (Oppo) and of Foxconn or Bharat Fih Ltd. (contract manufacturer for Apple and Xiaomi). The large amounts of imported raw materials indicate assembly for these top-selling brands. Needless to add, increasing market share for Chinese firms has come at the expense of Indian firms, who never developed design and other capabilities, and kept focussing on importing components in knocked-down format and assembling the phones here.

Table 7: Performance of selected foreign firms in Rs. million

	Oppo Mobiles India Pvt. Ltd.		Bharat Fih Ltd.	
Year	Sales	IRM	Sales	IRM
2019-20	385424.3	332485.2	263922.2	--
2020-21	427658.2	--	158197.2	--
2021-22	569407.4	--	181183.4	--
2022-23	516868	--	115776.3	--

Note: IRM – import of raw materials

Source: Prowess, Centre for Monitoring Indian Economy

3.5 Lack of Intellectual Property

Publicly-funded research in electronics has helped India acquire some capability in electronics. For example, in 1984, a public laboratory called Centre for Development of Telematics (C-DOT) was established to conduct research in telecommunications equipment. C-DOT was expected to transfer the technology developed to public and private sector firms. The lab successfully developed a digital switching equipment for smaller rural exchanges; as a result, the market for switching equipments became contestable,[19] eventually leading to reduction in the average price of switching equipments (Mani, 2005). Thus, R&D intervention in the electronics sector has led to benefits to the economy.

India has neglected similar investments in mobile technology, and has not generated any intellectual property in the mobile phone manufacturing space. Mani (2019) notes that almost all the applicants for patents before the Indian Patent Office in mobile communications technologies are from abroad. Indian firms accounted only for 18 patent applications (and not patents) among the thousands of applications and patents that have been filed and awarded. Most of the patents in the next generation mobile technologies (such as 4G and 5G) were held by non-Indian firms, making Indian manufacturing firms dependent on them for the technology (Mani, 2019). In the last few years, there have been attempts by the Indian government to come up with its own 6G standards[20].

To summarize our discussion, if India wants mobile investments to generate livelihoods on a sustained basis and contribute to the revival of manufacturing in the country, then it is important for India to build capabilities, not only by investing in mobile technology research, but also by making itself indispensable in the production plans of MNCs and component manufacturers. We believe that the South Korean example clearly shows that building capabilities is a long-term project, a path that has larger investment commitment with lesser returns in short-run. Given today's multilateral trade context, in the next section we point out a few lessons from the recent Chinese and Vietnamese experience[e] that can be used to formulate policy.

4. Observations and Future Choices

Amsden (1997) points out that governments of late-comer countries have played an important role in industrialization, by joining with the private sector to socially construct competitive assets (resources, capabilities, and organizations) rather than to create perfect markets. However, India being a WTO member has significantly reduced its options for national support policies (Ernst, 2014). It does not help that current policies, such as PMP and PLI, have opposite effects: PMP promotes imports substitution, while PLI promotes exports (Mishra et al, 2022).

Our analysis of the sector makes it clear that mobile manufacture in India is import dependent, with a lack of intellectual property. Import dependence is also reflected in an international comparison in the following table, where the ratio of exports to imports for mobile phone and its parts for China, India, and Vietnam have been put together.

Table 8: Mobile phone and parts - ratio of exports to imports

	Mobile phone			Parts		
Year	China	India	Vietnam	China	India	Vietnam
2009	22.3	1.1	0.3	1.6	0.1	0.5
2010	41.2	0.3	1.7	1.8	0.1	0.3
2011	49.2	0.6	6.3	1.6	0.3	0.2
2012	49.7	0.6	13.6	1.2	0.2	0.5
2013	57.7	0.4	19.6	1.2	0.3	0.2
2014	64.6	0.1	16.5	1.2	0.2	0.3
2015	41.5	0.0	18.0	1.2	0.1	0.5
2016	46.0	0.1	17.1	1.3	0.1	0.8
2017	169.5	0.0	16.0	1.2	0.0	1.0
2018	486.8	0.5	18.6	1.2	0.0	1.2
2019	286.0	3.9	19.4	1.3	0.0	1.3
2020	140.4	1.4	20.7	1.3	0.1	1.3
2021*	111.8	3.2	13.0	1.2	0.1	1.2

Note: * - Latest data available as on 1st May 2024.

Source: UN Comtrade

For the period 2009-2021, for mobile phones, China is miles ahead of India; Vietnam, which was behind India in 2009, overtook India the following year and continues to be much ahead. With respect to parts, it seems that China has been successful in establishing significant component production, as its export-to-import ratio is above one throughout the period. Vietnam was a component importer till 2016; however, post 2016, it seems to have set up some component production facilities, as the ratio has also risen above one. India's failure in component production can be seen from the close-to-zero ratio throughout the period.

This inference is also emphasized in a comparison of the competitiveness index for mobile handsets, computed by CII-NCAER (2022). This leads us to believe that Indian policy makers can probably learn from the Chinese and Vietnamese experience to decide on the path or paths that may help the sector.

Table 9: Competitiveness index for mobile handsets

Country	2018	2019	2020
China	3.64	3.21	2.97
Vietnam	8.19	8.25	6.73
India	`0.22	0.67	0.66

Source: CII-NCAER (2022)

4.1 Lessons from the Chinese experience[f]

As mentioned above, China followed multiple paths to enter mobile manufacturing – linking of domestic market access and technology transfer for MNCs; industrial policy to shield and nurture domestic firms; and investment in indigenous standards.

Brandt and Thun (2011) point out that when handset manufacturing activities first began to shift to China, MNCs were focussed on exports, as the domestic market was negligible. Within a decade, China became the largest market in the globe; however, for a variety of reasons MNC producers did not change their component sourcing strategy for handsets that were sold in China.

- First, other than minor changes in the user interface, the products demanded by the Chinese market and the global market were similar. Economies of scale obtained by ensuring same design of a low-end handset across markets discouraged use of local suppliers.
- Second, modular architecture allowed for changes in the respective modules, without impacting other modules and hence continuance of the same sourcing strategy. Common global platforms allowed Nokia to price below competing OEMs.
- Finally, low transportation costs made imports of small but high value electronic parts and components competitive.

As a result, Xing (2014) finds that in 2009, China's value add was 3% of its exports of iPhones and laptop PCs. This situation, however, seems to be changing, as Chinese local firms seem to be acquiring capabilities, because of which they are now supplying components that go into the production of an Apple phone. To understand the involvement of Chinese firms in its production, Xing (2019) deconstructs the iPhone X.

- Core components embedded in the printed circuit board assembly (PCBA) were being supplied by non-Chinese companies, and Chinese companies supplied only a tiny share of non-core components of the PCBA.
- However, 10 local companies supply parts for component manufacturing, for example, function parts for touchscreen module, filter for 3D sensing module, coil module for wireless charging, PCB, speakers, RF antenna, battery pack, glass cover, stainless frame, and camera module.

The mechanism of capability acquisition for all but one of these firms is not clear; the Chinese firm that supplies PCBs acquired its capability by buying out the American firm that used to supply PCBs for Apple iPhone manufacture[g]. Value addition by Chinese firms that supply components account for 25.4% of the manufacturing costs of iPhoneX, while that as a percentage of the retail price account for 10.4% (Xing, 2019).

The emergence of the Shanzhai cell phone industry not only helped expand the Chinese domestic market, but also saw the rise of Chinese brands (Ding and Pan, 2011). These brands could enter the mobile market primarily due the lowering of technological barriers by Mediatek – a chip maker from Taiwan – which saved new mobile phone makers the high cost of R&D. These local firms took

advantage of the trend of platform-based development in the migration towards smartphones. Using their knowledge of local preferences and needs, these local firms catered to the demand at the lower end of the market and became market leaders.

For example, in 2011, Xiaomi began to sell high-end phones at low prices, using unique and innovative strategies. The company generated revenue through selling apps, and introduced a customised version of Android which had additional functionality. As a result, by 2014, Xiaomi had over taken Samsung to become the leading smartphone vendor in China (Chuang, 2016).

This implies that there is scope for firms from latecomer countries to increase their value addition by focussing on the downstream activities such as branding, marketing etc. It is interesting to note that, while the value added by Chinese firms supplying components accounts for 15.4% of the production cost of a Xiaomi phone, the value addition by Chinese firms increases to 41.7% of the retail price for a Xiaomi phone (Xing, 2019).

4.2 Lessons from the Vietnamese experience

Table 8 showed that Vietnam has overtaken India both in mobiles and parts production; however, literature is divided on its impact on the level and depth of local industrial development in Vietnam.

- Tran and Norlund (2015) mention that integration into global markets has not implied that access to knowledge and technology transfer has become easier, implying that positive spillover effects were absent.
- Local firms provided only labour-intensive assembly of low value components (Ohno, 2009 and Vind, 2008).
- Offering higher salaries, MNCs hired the best talent, weakening the absorptive capacity, and, hence, upgrading of domestic firms (Vind, 2008).
- Many a times, MNC sourcing strategy worked against local linkages, for example, Samsung relied heavily on its Korean suppliers who co-located with it in Vietnam. Four among Samsung's 67 suppliers are local firms, who supply packaging materials (Sturgeon & Zylberberg, 2016).
- Lack of domestic capability will also hinder policy push towards local industrialization. For example, in 2015, the Vietnam Ministry of Industry and Trade announced that Samsung would source simple parts for its mobiles and tablets from local suppliers (Sturgeon & Zylberberg, 2016). While a workshop with 200 local firms was held by Samsung and the Vietnamese government, reportedly, none of the firms were up to the task. Instead of direct local linkages, Samsung planned local linkages for their tier 1 suppliers (Sturgeon & Zylberberg, 2016), which as per table 8, seems to have worked.
- Masina and Cerimele (2018) state that price competition in today's markets does not allow local firms to enter MNCs production networks, as local firms neither have the technology nor the experience to produce quality goods. Moving production to developing countries is

thus a MNC strategy to reduce costs; which implies that late-comer countries face a complex environment to achieve industrial deepening and upgrading (Masina & Cerimele, 2018).

Samsung's mobile phone assembly plant in Vietnam produces 40% of Samsung's global mobile phones (WDR, 2020). However, what WDR (2020) does not point out, but Nakamura and Marukawa (2024) do, is that Samsung procures components from its subsidiaries that have set up plants in Vietnam. A plant to produce cell batteries came up in 2010; camera modules, capacitors, and other components plant started production in 2014; display plant came onstream in 2015. PCBs are produced locally by Korean suppliers of Samsung.

Despite these foreign investments, Nakamura and Marukawa (2024) point out that the share of domestic inputs has gradually declined, and has stagnated at around 35% since 2012, in stark contrast to electronic industries experiences of other major ASEAN nations. They emphasize that low and decreasing domestic value added may be due to manufacture of upgraded products (e.g. smartphones rather than feature phones) at Samsung's facilities. They conclude that local manufacturers can supply only a few parts and packaging materials, as creating domestic backward linkages (composed of highly-integrated capital and technology-intensive components) is not easy, and these important components are unlikely to be manufactured by firms in developing countries because of lack of capabilities. Nakamura and Marukawa (2024) suggest encouraging production of printers rather than production of mobile phones in developing economies such as Vietnam, because they offer more opportunities for local manufacturers to supply parts.

Lee and Jung (2015) point out that Samsung set up a huge factory in Vietnam to benefit from lower costs in the assembly stage of production using local labour. The company claimed that if a phone was produced in Vietnam and not in South Korea, it saved the firm US$5.7 per mobile – which is a huge amount considering the Vietnam production capacity is 120 million units per year. Samsung's internationalization of production has brought a substantial cost reduction, and thus larger profits available for reinvestment.

Another issue in late-comer nations is 'enclave economy', wherein local firms have not been able to integrate into global electronics value chains (Pham *et al*, 2020). As per them, the main barrier preventing linkages of local firms with MNCs is lack of skilled labour. Local firms do not invest in upgrading their technological capability as MNCs encourage local competition, resulting in lower margins. Moreover, MNCs establish local linkages for the incentives they receive from the government, while local firms take on increased risks without government support (Pham et al, 2020). By 2017, 52% of the 600 foreign electronics firms operating in Vietnam were components and part producers. Local firms primarily operated in low-end segments of the value chain (Pham et al, 2020).

4.3 Future choices for India

It has been more than a decade and a half since the first mobile was assembled in India, however, the sector is yet to see any major backward linkage creation. In 2005, Nokia – which ran the largest assembly plant at that time – and its seven supplier companies were expected to usher electronics

hardware manufacturing into the country. Phones and other accessories were assembled using the components imported without duties (Dutta, 2016). The ceasing of operations at the Nokia plant due to a tax dispute alerts us to the fickleness of investments into assembly plants.

In the past eight years, well-known brands such Apple, Xiaomi etc. have started local assembly through their contract manufacturers in India. Though there is not much scholarly literature that has evaluated its impact, it is reasonable to expect a Vietnam kind of experience. The thrust on the PLI emphasizes the belief of the government on export-led industrial development strategy. Among China, Vietnam, and India, however, ICEA & EY (2020) points out that the effective cost of manufacturing mobile phone is cheapest in China, followed by Vietnam, and then India. Thus, Vietnam retains its advantage over India in commodity segments. This implies exports from assembly units with or without PLI will face stiff competition from Vietnam.

Another recent study (Ikdhvaj & ICEA, 2023) compared India's import tariffs in 120 tariff lines for electronics with those in China, Mexico, Thailand, and Vietnam; they found that a larger proportion of imports of the competing economies entered duty free compared to that for India. The study also states that higher Indian tariffs on sub-assemblies and components result in an increase in cost of production in India, which can make going tougher for the assembly units operational in the country. This implies that a cost-competitive manufacturing ecosystem based on government incentives or subsidies alone may not be the best possible path for India. In other words, just relying on PMP plus PLI may not do the job for us.

In addition, it may be useful to point out that although export-led industrial development has been successful in China; it has been criticized as "unsustainable development, low value added, low technology input, labour- and resource-intensive, over dependent on exports and TNCs, and environmentally and socially unsound" (Chuang, 2016).

Iyer (2022) points out that assembly of phones which is at the lowest part of the 'smile' curve[21] is happening in India. This implies that the future path India takes should lead us up either on the right-hand side or left-hand side of the 'smile' curve. Given the policies of PMP plus PLI that we have already implemented, we believe there are at least three policy options that may help India in this journey.

- First, like the Chinese, we need the government to continuously invest in indigenous standards[22] and technologies, which down the road[23] will help build up India's capabilities. These capabilities will help India to strengthen her mobile manufacturing ecosystem, which hopefully, by then, PLI[24] would have built. Adoption of the indigenous standards and technologies in our domestic market has the potential to multiply India's capabilities in the sector.
- Second, literature has shown that modularization, ITA-1, and lower transport costs have hindered the development of domestic backward linkages. The Vietnamese experience is clear: backward linkage creation with domestic firms is difficult. Hence, for better outcomes for the investments that come in through the PLI, India may want to emphasize domestic backward

linkage creation or a minimum domestic value addition in all mobile phones manufactured in India. For this the Indian government should announce incentives for local firms to establish linkages with mobile manufacturing MNCs.

- Third, given India's huge but relatively low value domestic market, local Indian firms can learn a lesson or two from the strategy followed by the Chinese in their domestic market. Chinese firms such as Xiaomi have shown that there is scope for firms from latecomer countries to increase their value addition by focussing on the downstream activities such as branding, marketing etc. A first step for Indian firms could be investing in R&D capability which will help them understand local needs and create a unique selling point.

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Notes

Editor's note:

A note of dissent from the anonymous referee and the author's response –
While the paper was approved for publication by the anonymous reviewer, they did stipulate that their comments and the author's response should be published along with the paper to reflect the referee's dissent on the conclusions drawn from the industrial policy and manufacturing experience of Asian countries. The notes below with numerical superscripts are standard endnotes and those with superscripts of alphabets are the referee's comments and the author's response.

[#] This paper has been a spin-off of a larger work 'Industrialization for Jobs and Growth: A case study of Cellular Mobile phone manufacturers in India', by the same author, supported by the Ford Foundation-IGIDR project 'Industrialization for Jobs and Growth'. Ref: Iyer, C.G. (2020). Industrialization for Jobs and Growth: A case study of Cellular Mobile phone manufacturers in India, paper written for the Ford Foundation-IGIDR project 'Industrialization for Jobs and Growth'.
A major part of this project has been published as a CDS Working paper 502. Ref: Iyer, C.G. (2021). Mobile Phone Manufacturing in India: A study of few characteristics. Working paper No. 502, Centre for Development Studies, Thiruvananthapuram, Kerala, India.
A brief version of the FF project & CDS working paper was published as "Mobile Phone Manufacturing in India: A Study of Few Characteristics" in the EPW on 19 February 2022.
I want to thank the anonymous referee whose two rounds of comments have considerably improved the paper. I also thank Mr. V. Sriram (CDS Chief Librarian) for his prompt response to all my paper requests. I am responsible for any errors that remain.

[1] Four firms – LG, Samsung, Hyundai, and Maxon – were responsible for the production of CDMA systems (equipment, facilities, and handsets). Mobile telecommunication service providers were instructed by the Ministry of Information and Communication to buy the systems from these four firms that had heavily invested in setting up production units (Park, 2013).

[2] The global firms chose the Global System for Mobile Communications (GSM) technology.

[3] Chang and Zach (2019) mention that, conditional on improving export performance, the Korean government also provided export subsidies. Given the small domestic market, this may have incentivised the CDMA manufacturers to focus on exports.

[a] The referee commented that "*that co-development with an international partner plus support for early deployment was the lesson here.*" We agree with the comment, however, from the South Korean experience we want to focus on the broader point of capability development. Of course, international collaborations is one strategy to achieve capability development.

[4] This is surprising given the fragmentation of production and relevance of GVCs.

[b] Since CDMA/GSM is just one part of the mobile phone, to get a complete picture of the South Korean experience, the referee commented that it may be worthwhile to investigate the South Korean experience in other segments of mobile phone production. The referee's observations on investigating other segments are well taken, however, in this paper we summarize Taiwan and the South Korean experience to emphasize the importance of capabilities, hence do not focus on all the segments.

[5] Imai & Shiu (2007) sum up this success as a marketing-focused strategy based on borrowed technology.

[6] 3G implies the third-generation wireless mobile technology.

[7] As shown by the South Korean example.

[8] Starting in the late '80s and early '90s.

[c] This inference of ours from the reading of Ernst (2014) has been challenged by the referee through the following comment "*This claim needs a lot more evidence. Vietnam etc were also signatories to the ITA-1. India got significant relaxations for increasing import tariffs. Nokia production began after ITA-1 implementation in India. So how is ITA-1 to blame? How did it discourage investors from scaling?*" & "*Seems like a correlation which is true only for India which is being proposed as a causation. Ref: https://takshashila.org.in/research/analysing-indias-position-information-technology-agreement*". We encourage the reader to read Ernst (2014) and the reference cited in the referee's comment for further clarifications.

[9] Data for other sub-segments are unavailable from 1997, hence have not been reported.

[d] The referee commented "*why did that not happen in China and Vietnam? Their experience is covered in Paper Tigers, Hidden Dragons (Fuller)*". Our response was "*As mentioned later, the Vietnamese experience is the same of no domestic backward linkages.*"

[10] A new scheme called the Remission of Duties or Taxes On Export Product (RoDTEP) has replaced MEIS starting 1 January, 2021. This new scheme is World Trade Organization (WTO) compliant. However, at the time of writing this paper, the rates under RoDTEP had to be finalized and notified. Source: https://www.livemint.com/news/india/government-caps-export-incentives-under-meis-at-rs-2-crore-11599033075428.html, accessed on 28 September 2020.

[11] In September 2019, Taiwan has raised a WTO complaint against the duties levied on few goods under the PMP. A panel to look into the complaint has been constituted in September 2020.

[12] As shown in table 5, given the structure of the global mobile phone industry, increasing exports in no way implies that mobile manufacturing in India is competitive.

[13] https://www.outlookbusiness.com/pixtory/graphically-speaking/lord-of-the-rings-4794, last accessed on 23 June 2020.

[14] An industry insider mentioned that components are being imported without duties using ITA-1 or FTA provisions.

[15] Annual Survey of Industries (ASI) is the principal source of Industrial Statistics in India; see http://mospi.nic.in/annual-survey-industries, for further information.

[16] For select mobile models - Apple iPhone7, Samsung Galaxy 7, and Huawei P9.

[1717] Ding and Pan (2011) note that the Shanzhai system - world's largest cell phone industrial cluster - comprised of thousands of small firms that relied on a Mediatek baseband chipset and sold primarily in the North Huaqiang market in China.

[18] https://www.livemint.com/Companies/UkSpqypNBO7Jb2LnZyCizL/A-bright-spot-for-Modis-Make-in-India-Smartphone-manufac.html, last accessed on 8 February 2019.

[19] C-DoT-designed digital switching equipment was produced by 50 manufacturers that C-DoT identified, trained, and licensed the technology to. A majority of components for the equipment was sourced from 372 local component manufacturers, who invested a total of Rs. 4.5 billion ($150 million) by 1995, employing some 20,000 personnel (Ray and Ray, 2010).

[20] See https://dot.gov.in/circular-and-notifications/3199, last accessed on 11 June 2024.

[e] India has a lot to learn from South Korea and Taiwan, however, in this paper we wish to focus only on the recent experiences of China and Vietnam. The referee's comment is reproduced here "*why not employ the South Korea or Taiwanese strategy? Might be useful to emphasize the difference here since those cases are covered in the first part of the paper. And in China too, how did Huawei climb the innovation ladder? That might be useful to add for the IP section.*"

[f] The referee commented that "*In this case, you are agreeing that China's strategy to globalise first and localise later worked. In South Korea's case, the paper is firmly saying the opposite.*" Our response was "*The aim of section 4.1 is to present evidence. Given different starting points as well as changing global environments, what works for one country may or may not work for another.*"

[g] For this sentence, the referee commented that "*There is a long-standing notion that wherever Apple has its FATP, it is in its interest to develop domestic sourcing in order to meet the gruelling demand of getting a new phone out every Christmas.*" Our response was "*We have just presented a summary of Xing (2019). Interested reader is encouraged to read the paper.*"

[21] Smile curve is a graph of value added (Y-axis) versus upstream, midstream, and downstream production activities (X-axis).

[22] Indian government has been making efforts in the past 3-4 years to come up with its own 6G standards. See https://dot.gov.in/circular-and-notifications/3199, last accessed on 11 June 2024.

[23] As we have seen in the Korean and Chinese example.

[24] The government has indicated that mobile PLI may be extended beyond 2026. See https://www.financialexpress.com/business/industry-mobile-pli-may-be-extended-beyond-2026-3497936/, last accessed 11 June 2024.

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