BENEFIT-COST ANALYSIS

DIGITISATION

Benefits and costs of digitisation interventions in RAJASTHAN

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RAJASTHAN PRIORITIES AN INDIA CONSENSUS PRIORITIZATION PROJECT

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TATA TRUSTS

Part 1

Costs and Benefits of Connecting Rural Households to the National Optic Fibre Network in Rajasthan

Rajasthan Priorities
An India Consensus Prioritization Project

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Academic Abstract[1]

National Optical Fibre Network (NOFN), an ambitious initiative to trigger broadband revolution in rural India, is creating a robust middle network infrastructure layer to connect gram panchayats of the country through broadband connectivity. This program has been under the scanner due to delay in timeline and the quality of its services. Various telecom analyst and social scientists have criticized the program and suggested their recommendations to improve the program. This paper calculates the major cost and benefits of connecting rural households to NOFN. We find that though there is a considerable cost of connecting the remaining gram panchayats and households, the benefits are much higher. We find a positive benefit cost ratio of 10 at the 5% level using wired infrastructure to connect households.

[1] The author would like to thank Brad Wong and Amit Sharma for their comments, valuable inputs and constant support which helped completing the paper to a large extent.

Policy Abstract

Overview

High-speed broadband is transforming the lives of millions. Developed and developing countries have recognized the potential of broadband and investing in building broadband infrastructure as part of their national agenda. 'Access to broadband' has become critical, making the development of its infrastructure a priority for the Government and the industry. In September 2010, broadband penetration in the country was 0.8% against a teledensity of 60.99. The target set for the year 2010 was 20 million, however, the number of broadband connections was only 10.3 million. India is one of the largest telecommunications market in the world with over 1 billion subscribers. Therefore, it recommended the establishment of a National Broadband Network connecting all habitations with population of 500 and above. To achieve this, the Indian Government took a commendable step in 2011 by commissioning the National Fibre Optic Network (NOFN) with an investment of INR 21,000 crore to connect 2,50,000 gram panchayats with a speed of 100 Mbps.

In 2015, NOFN was restructured as a BharatNet under flagship program, 'Digital India' aiming to connect all gram panchayats and villages and the existing institutions (like government offices, public health centres, schools, banks, etc) through broadband. Implemented in two phases, the point of presence (PoP) with optical connectivity will be established at all gram panchayats by 2019. Further, it is expected that individual housholds will be connected by giving licence to private enterprises to connect the last mile and on-sell bandwith. NOFN was established to enable key services like e-governance, education, health, banking and agriculture in rural regions of the country. With the central government being directly engaged in the implementation of the program, the state has had minimal role in executing the project. The Union Cabinet has approved the project at a total estimated cost of Rs. 42068 crore which includes 11,148 crore for Phase I and 30,920 crore for Phase II[2]. The expenditure for NOFN for the duration 2014 to January 2017 is Rs. 8384 crore. [3]

The Universal Service Obligation Fund (USOF) under the Ministry of Communications is providing all the funding for the implementation of the project[4]. As on June 2017, the number of broadband

[2] BBNL Annual Report 2016-2017; http://www.bbnl.nic.in//admnis/admin/showimg.aspx?ID=1025; accessed on 14.5.2018
[3] PIB Press Release http://pib.nic.in/PressReleaseIframePage.aspx?PRID=1506002; accessed on 14.5.2018
[4] Agreement For Support from USO Fund For Creation, Operation and Maintenance of the National Optical Fibre Network (NOFN) for Provision of Broadband Connectivity to the Panchayats to be executed by Bharat Broadband Network Limited

connections in India has risen to a whopping 300 million, a 200% increase in a short span of five years, albeit from a small base.

Broadband holds the potential to have a significant impact on economic and social progress and to transform the economy. There are several studies that demonstrate a robust connection between GDP growth and broadband with effects ranging from 0.9 to 1.4 pp for a 10% increase in penetration (Czernich et al. 2011, Koutroumpis 2018, OECD 2012, KPMG & CII, 2013). The use of broadband at household level is likely to have economic impacts, either by allowing workers to work from home or establishing the home-based firms. Other potential indirect benefits include the provision of using broadband connectivity by other sectors such as online education, tele-health services and opening new emerging markets that ride on broadband connectivity.

Kelly (2012) argues that the impact of broadband on the national economy is only possible when the supply of broadband infrastructure is available and functioning adequately. However, the demand of broadband is an important factor to make substantial network investments worthwhile. This multiplier effect of broadband can boost GDP, productivity and employment growth, provided there is absorptive capacity, to learn and incorporate broadband capabilities into other sectors to realize such benefits.

Intervention: Connecting the last section of the unconnected households through NOFN

Currently, 8155 GPs in Rajasthan are connected to NOFN via 23,912 kms of optic fibre. 1745 GPs remain to be connected. We analyse the cost and benefits of connecting the remaining GPs through NOFN, and the households that take up connections thereafter. Estimates in this paper suggest broadband would reach 17% of rural households by 2035, and 33% by 2067. Benefits are measured through increased GSDP enabled by increasing broadband penetration.

Implementation Considerations

Over the years, many telecom analysts and social scientists have criticized NOFN as an initiative. Issues like extending the launch of NOFN project from 2012 to 2014; inability to lay the optic fibre

(BBNL) Under Universal Services Obligation Fund, The Indian Telegraph (Amendment) Rules, 2012' http://www.usof.gov.in/usof-cms/GagendaPdf/NOFN_Agreement.pdf accessed on 14.5.2018

within timeline by service providers, non-availability of G2C services and sustainable framework are some issues that have been continuously raised.

Costs and Benefits

Costs

There are four categories of cost associated with this intervention 1) cost of connecting the remaining GPs and ongoing maintenance; 2) cost to connect remaining households and ongoing maintenance; 3) upgrading the data centre cost to connect institutions (such as public health centre (PHC), schools, government agencies, etc) and 4) costs of accessing broadband services.

Data from published reports suggests that it costs Rs. 29 lakh to connect one GP to NOFN, while the cost of connecting one household is about Rs. 7,400. Maintenance costs for the network are Rs. 1.5 lakh per GP, and Rs. 372 per HH. Upgrading data centers requires a cost of Rs. 27 lakh per year, while costs of accessing broadband are Rs. 300 per HH. Total undiscounted costs until 2067 are presented below and total 26,502 crore. The cost at a 5% discount rate is Rs. 7,780 crores.

Costs of connecting NOFN to households until 2067 (figures in 2016, Rs. Crore)

Cost of connecting remaining GPs	508
Cost of connecting HHs	2,673
Operations cost for NOFN including data center upgrades	16,242
Operations cost for HH connections	3,919
Costs of accessing broadband	3,159
Total (undiscounted)	**26,502**

Benefits

Using the relationship from Koutroumpis (2018) we estimate the annual boosts to GSDP arising from the pathway of fixed broadband growth across the entire state attributable to the NOFN. After three years the boost to GSDP is small, measured at only 0.02%. By 2035 the boost is 0.1%, by 2050 the boost is 0.2%, and by 2067 it is 0.3%. Note that these GDP jumps *accumulate and compound*, such that small boosts to GDP have significant benefits over a 50-year period. The incremental boost to GSDP is Rs. 135 crore by 2020, Rs. 3,233 crore by 2035 and Rs. 27,299 crore by 2067. In GDSP per

capita terms, the corresponding values are Rs. 8, 345 and 2,769. Total benefits until 2067 equal 81,552 crore at a 5% discount rate. The benefit-cost ratio (BCR) of the intervention is 10.

Summary BCR Table

Interventions	Discount Rate	Benefit (INR in crore)	Cost (INR in crore)	BCR	Quality of Evidence
Providing the NOFN connectivity from gram panchayat (GP) to household (HH) level using wired infrastructure	3%	156,022	11,878	13	Medium
	5%	81,552	7,780	10	Medium
	8%	34,455	4,763	7	Medium

Source: Author Calculations

1. Introduction

Internet continues to influence every aspect of life from education, health care to businesses. Economic activities, both at domestic and international level, are increasingly dependent on internet for their efficient and effective functioning. The rapid deployment of broadband infrastructure and internet around the world is not only giving opportunities to local businesses to go international but also creating new opportunities. It is also changing the nature of method to deliver content and service through conventional and non-conventional channels (Wolf, 2000). The roll out of high-speed broadband Internet services brings changes in the nature and shape of innovations in the digital domain (Rao, 2001). Due to its ability to connect global markets, the internet is changing fundamental nature of global business by connecting people and local businesses overcoming geographical barriers (Sprano, 2000). Apart from its economic benefits, effective broadband infrastructure also enables citizens to participate in the governance system by improving access to information resulting in a more accountable, transparent and efficient public service delivery system.

The impact of broadband internet on the economy is substantial. Developed countries or high-income economies with an average of 10 broadband subscribers per 100 people would have enjoyed a 1.21 percentage point increase in per capita GDP growth. Similarly, developing countries have enjoyed 1.38 percentage point increase in their GDP for each 10 percent increase in broadband penetration (Qiang, 2009).

Amongst various broadband services, the Government of India initiated several initiates such as National Broadband Network, National Optical Fibre Network, National Knowledge Network, and Digital India to promote demand for broadband access and to provide last mile internet services in rural areas of the country. Small enterprises and SMBs (small and medium businesses) have begun to realise the long-term benefits of mobility and digitization. An increase in 1 percentage point in broadband penetration growth results in 0.028 percentage points increase in the employment rate (International Telecommunication Union, 2012). In the last 10 years, telecommunications sector as percentage of India's GDP has steadily

increased from ~ 1.2 % in 2002 to ~ 6.9% in 2012-2013, which clearly indicates that telecom sector has significantly contributed in the Indian economy[5].

National Optical Fibre Network (NOFN), initiated by the Government of India, is one of the largest schemes to provide the broadband connectivity in 250,000 gram panchayats (GPs)[6] of the country. Though the project was approved in 2011, the physical infrastructure roll out commenced in the latter half of 2014. The project is executed by Bharat Broadband Network Limited (BBNL) a telecom infrastructure provider set up by government of India. Rajasthan is one of the top performers in implementing NOFN programme by connecting 8155 GPs out of 9900 GPs[7].

This paper calculates the costs and benefits derived from; i. connecting the unconnected GPs through NOFN and ii. Connecting rural households to Broadband using the NOFN infrastructure. The present value of total cost of the intervention for 50 years is estimated at INR 7,780 crores at 5% discount rate.

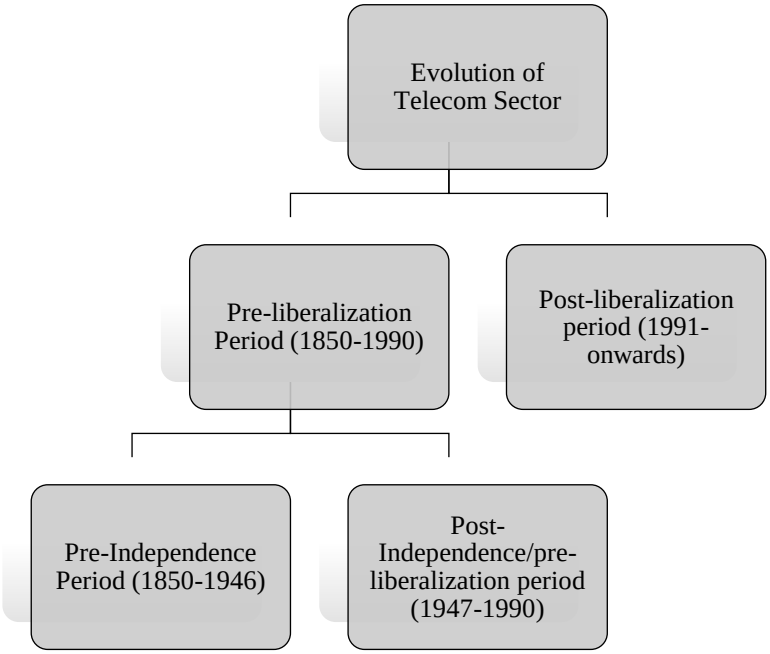
The paper has adopted the approach of providing NOFN connectivity from gram panchayat (GP) to household (HH) level using wired infrastructure. Calculating the benefits for 50 years, the present value of total benefits is around INR 81500 crore at a 5% discount rate, leading to cost-benefit ratio of 10.

2. Evolution of telecommunications in India

The evolution of telecom sector can be categorized as pre-liberisation period and post-liberisation period (Fig 1).

[5] Emerging Global Economic Situation, January 2014. See: http://finmin.nic.in/workingpaper/EmergGlobalEcoServiceSector.pdf
[6] Gram Panchayat (also known as village council): https://en.wikipedia.org/wiki/Gram_panchayat
[7] BBNL website; http://www.bbnl.nic.in/index1.aspx?lsid=577&lev=2&lid=471&langid=2 accessed on 14.5.2018

Fig 1: Evolution of telecom sector in India



Until the mid-1980's, the telecommunication sector in India was functioning as a government department. Mahanagar Telephone Nigam Limited (MTNL) was established in 1986 to provide telephone and telex services under a non-exclusive license in the two largest metropolitan cities of Delhi and Mumbai. In the same year, Videsh Sanchar Nigam Limited (VSNL) to provide the international long distance (ILD) services (Jain, 2002). The Telecom Commission was established in 1989 as an executive body under the Ministry of Communications with administrative and financial powers of the Government of India to deal with various aspects of telecommunications and to implement government policy in concerning telecommunications matters.

In October 2000, Department of Telecommunication Services (DTS) was corporatized and new entity was formed to provide the telecommunication services in the entire country, except Delhi and Mumbai. The first telecom policy came into existence in 1994 to liberalise the telecom sector by opening up of the telecom sector in basic services as well as value added services such as cellular mobile telephone services (CMTS), radio paging, and VSAT services. It also allowed participation of private companies in the telecom sector except national long distance (NLD) and international long distance (ILD) services.

During 1997-2000, two major agencies came into existence - Telecom Regulatory Authority Act was passed by the parliament and TRAI became an independent regulatory authority for the telecom sector in 1997 and the government created Telecom Disputes Settlement and Appellate Tribunal (TDSAT) in January 2000 with adjudication and dispute settlement power.

National Telecom Policy (NTP) – 1999 opened the market for private players in all segments. The policy clearly recognized the need for strengthening the regulatory regime and restructuring the departmental telecom services into the public sector corporation so as to separate the licensing and policy functions from the government. After 2000, the Indian telecom sector has seen major significant policy reforms. The regulatory reforms in the telecom sector from 2000-2011 can be broadly classified into the following three phases:

- Phase 1 – 2000–2003: Telecom sectors were opened up to competition.
- Phase 2 – 2004–2007: Regulato-encouraged competition and also set the stage for future growth.
- Phase 3 – 2008–2011: More choices were brought in for consumers in terms of technology and services.

To widen the reach of telephony services in rural India, the Universal Service Obligation (USO) policy came into an effect on 2002. Initially, USOF was established to provide the fundamental access to 'basic' telegraph services to people in the rural and remote areas at an affordable rate. In 2004, the Government of India approved the National Broadband Policy (as NTP – 2004) aiming at enhancing the quality of services through initiatves like e-education, tele-health, egovernance, information services, etc. Prior the implementation of NTP-2004, the broadband coverage was significantly low as compared to other Asian countries. The penetration of broadband, Internet and personal computers were at 0.02 per cent, 0.4 per cent and 0.8 per cent respectively during the time of implementation of policy (TRAI, 2003). Till 2004, there was no uniform standard for broadband access and connectivity. Internet access was available at various speeds in a range from 64 kilo bits per second to 128 kilo bits second. The high-speed Internet connection through broadband was introduced in the NTP-2004. After the introduction of NTP-2004, the scope of USOF was widened to provide the subsidy for enabling all types of telecom services, including

broadband connectivity, creating of infrastructure such as Optical Fibre Cable (OFC) in rural and remote areas (Department of Telecommunications, 2008-2009). The implementation of 3G technologies was introduced in wireless broadband by removing the wired line last mile bottleneck in 2010. The NTP -1999 acted as catalyst for growth in telecom sector. In February 2012, the number of telephone connections were 943 million as compared to 41 million in December 2001[8]. This resulted contribution of 3% to India's GDP, the demand for broadband Internet connectivity was increasing to accelerate the growth of the economic and social sectors. However, the expansion of telecommunications and broadband connectivity was yet slower in rural areas as compared to urban areas. The National Optical Fibre Network (NOFN) project was envisaged e by the Telecom Commission in June 2011 with a mission to create a robust middle-mile infrastructure for providing broadband connectivity to Gram Panchayats. A year later, the National Telecom Policy 2012 (NTP - 2012) was conceived with a vision 'Broadband on Demand' to leverage telecom infrastructure to enable all citizens and businesses both in rural and urban areas to participate in the digital economy, thereby ensuring equitable and inclusive development of the nation.

3. Fixed broadband and mobile broadband: Opportunities & Challenges

The telecom sector in India has witnessed impeccable growth since 2000s. The teledensity, which was 12.99 as on March 2006, has reached to 92.810 as on March 2018. With 252 million Internet users, India ranks third worldwide in terms of sheer total of people

[8] National Telecom Policy 2012; http://meity.gov.in/writereaddata/files/National%20Telecom%20Policy%20(2012)%20(480%20KB).pdf accessed on 14.5.2018
[9] TRAI annual report 2005-06; accessed on 25.5.2018
[10] TRAI annual report; March 2018; accessed on 25.5.2018

connected to the interent. Mobile broadband penetration is 16.8 percent. However, the fixed broadband penetration in India is 1.4 percent11. The 3G-based mobile broadband services in India are driven both by demand and supply of side factors. The introduction of new innovative services and applications, enhanced user experience and decreasing prices of 3G enabled handsets are key drivers for mobile broadband in India. Mobile broadband is contributing heavily to the growth of digital economy broadband, however the household Internet penetration is still low. Challenges like the high cost of infrastructure, lower and slower returns on investment, regulatory challenges and uncertainty, and enormous amount of investment in 3G and 4G spectrums are some of the challenges for thet telecom companies to expand in rural India.

Another challenge is poor availability of backhaul connectivity. Unlike urban areas where OFC is largely deployed to provide the backhaul connection, about 80% of the rural BTS are on microwave system. Due to the lack of backhaul connectivity, only wimax and mobile broadband become possible solutions for providing connectivity in remote areas. Thus, to make the society 'information highway', the NTP-2012 conceived to bring the broadband connectivity in remote areas of the country.

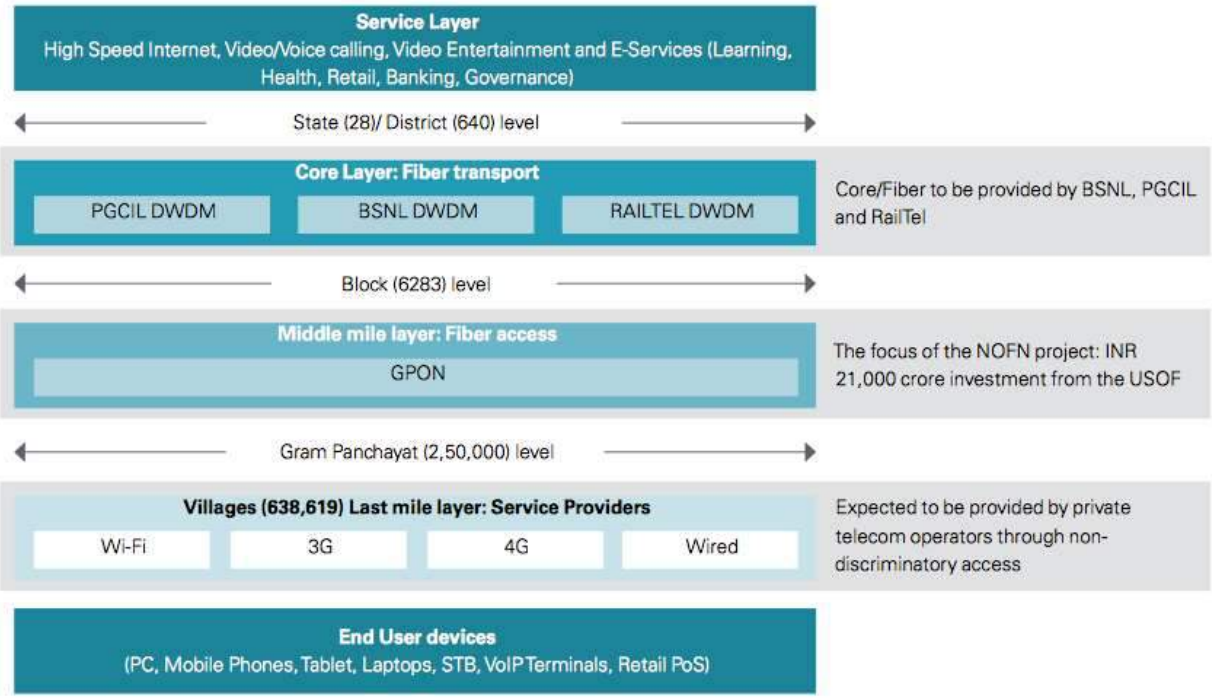
4. NOFN and the broadband infrastructure in India

Only 0.53% of India broadband connections were connected through optical fibre in 2010. In the same year, the TRAI released a report, recommending the growth of broadband in India. In October 2011, the government of India approved the scheme to set up NOFN aiming to provide broadband connectivity up to village council level. For this purpose, the government formed a Special Purpose Vehicle (SPV), named 'Bharat Broadband Network Limited' (BBNL) for the establishment, management and operations of NOFN. It was decided that BBNL would be wholesale bandwidth provider who would provide non-discriminatory access to the NOFN infrastructure to all service providers. It was decided that existing central public sector undertakings (CPSUs) will deploy the NOFN infrastructure and it will be funded by USOF. These CPSUs are BSNL (Bharat Sanchar Pvt. Limited), RAILTEL, the telecom arm of the Indian

[11] https://telecom.economictimes.indiatimes.com/news/india-had-16-8-mobile-broadband-penetration-broadband-commission/60516269; accessed on 25.5.2018

Railways, and Power Grid Corporation (Srinivasan, 2004). Accordingly, the work was split State-wise between BSNL, RailTel and PGCIL in the ratio of 70:15:15.

Prior the implementation of NOFN, there was only 1.1 million Rkms (routes kilometers), covering the entire urban regions of the country and having limited presence in rural parts. BSNL accounted 60% of the fibre optic and was the only provider, which had point of presence in all the districts and 28,000 villages. NOFN was conceived as a project for connecting the state headquarter (SHQ) to district headquarter (DHQ) to block headquarter (BHQ) to gram panchayat. It was estimated that additional OFC of 301,000 route kilometers mainly from BHQ to the gram panchayats would be required (Mason, 2010).



Source: Adapted from 'Connecting India – Enabling Socially Inclusive Growth through National Broadband Network, Cisco, 2012'

The NOFN was rolled out in a phased manner at a cost of USD 4 billion (Srinivasan, 2014). Initially, the Telecom Commission approved a 3-phase implementation plan. The first 100,000 gram panchayats were to be covered in the first phase and to be finished by March 2014. However, the target was reduced to 50,000 GPs and to be covered by March 2015 (BBNL, 2015). The rest i.e. 150,000 GPs to be covered under phase-II by March 2015 (Srinivasan, 2014). However, the timeline for the first phase and second phase were extended a number of times. NOFN was reconceptualised and upgraded as BharatNet under framework of Digital

India in 2015. BSNL was responsible for laying NOFN in 18 states/territories, including Rajasthan. Since the rollout of NOFN in Rajasthan, 8155 GPs (23912 kms) are connected as on April 2018[12].

NOFN was largely envisaged as a governance project in which the GPs, the last tier of governace, would be seamlessly connected upwards to block, district and state level. However, the project also provides opportunity for last mile connectivity which means taking the connectivity from gram panchayats to the household level and to connect institutions (such as schools, public health centres, government offices, etc) at district, block and panchayat level. The current study looks into the cost and associated benefits for providing household broadband connectivity using the existing infrastructure of NOFN.

5. Implementation Challenges of NOFN in India

Broadband networks have become an integral part of knowledge economy especially for those activities that rely on the provision of data transformation, particularly in service sector. It helps in bridging the digital divide and bringing the information at the doorsteps of the people. Before economic liberlisaton in early 1990s, the telecommunication sector was completetly under the control of the government. Post liberalization, the sector got the much needed investment boost as different private players also entered (Dossani, 2005) and were also helped by various policy initiatives of the government.

The genesis of the National Optical Fibre Network (NOFN) can be traced to a White Paper issued in August 2010 by the office of the Adviser to the Prime Minister on Public Information Infrastructure and Innovation headed by Sam Pitroda. The paper was focused on connecting the gram panchayats with the governance tiers at the state and central level and also tracking various schemes and policies and the lowest level. It envisioned of strengthening the administrative capacity of the panchayats by providing broadband connection and internet services to leverage public information infrastructure at the grassroots in rural India. One World Bank study reports that 1.38 percent increase in per capita GDP of developing economies for every 10 percent increase in broadband penetration. The paper stated that

[12] BBNL website; http://www.bbnl.nic.in/index1.aspx?lsid=577&lev=2&lid=471&langid=1; accessed on 14.5.2018

access to broadband services would lead to a wave of economic and social growth in India like the way spread of voice telephony in the 1980s. Comparing the advantages and disadvantages of Digital Subscriber Lines (DSL), cable models, and wireless technologies, it identified that optic fibre is best mode to bring internet to rural India, given their long-term sustainability and reliability.

Later on, the Telecom Regulatory Authority of India (TRAI) called for a national broadband policy in rural areas with a population count of at least 500 people on the internet connectivity grid. To enable this, the cabinet approved the creation of a National Optical Fibre Network (NOFN) to provide the broadband connectivity in panchayats providing funds through the Universal Service Obiligation Fund (USOF). A special purpose vehical (SPV) was formed, named Bharat Broadband Network Limited (BBNL) to implement, execute and monitor the program through three agencies – BSNL, RailTel and PGCIL (also known as PowerGrid). During the time of launch of NOFN, the proposed timeline for completion was two years during which incremental optic fibre covering 500,000 route km would be laid. After the change of the government in 2014, NOFN was remaned as BharatNet in 2015 keeping intact the main objective of connecting of 250,000 panchayats with broadband.

Challenges of deploying NOFN broadband

Lack of accountability

An expert committee while evaluating the project stated that BBNL was not so effective as an execution agency. The project was marred by a lack of accountability and delays in decision-making because of excessive emphasis on cost controls, resuling in poor implementation.

There was no role of state governments, thus states were found to be aloof and not involved in active collaboration leading to delays and slow progress in the implementation. At sites where NOFN had been completed, repair and maintenance are in poor state due to lack of skilled staff. This has been compounded by erratic power supply and inadequate space to house and secure equipments and assets.

Delay in timeline

When the NOFN was launched as project under the aegis of the BBNL in 2011, the proposed timeline for completion was set two years. However, since then the timeline has undergone multiple revisions with the latest deadline pushed to December 2018. One of the main

reasons for the delays is that BBNL has not been able to take decisions in an autonomous manner, which slows down the process.

Increase in expenditure

The original budget for the project was INR 20,000 crores, which today stands at a recommended INR 72,000 crores. This year, the government has allocated INR 10,000 crores under telecom infrastructure.

Unavailability of affordable devices

Availability of compatible and affordable devices is a concern for improving the broadband connectivity in the country. Smartphone prices are coming down and the penetration is increasing continuously but still 71 percent feature phones in India cannot access high-speed Internet[13]. Similarly, in case of fixed broadband, the user need to purchase end user equipments like modems and splitters which cost more than an average Indian can afford.

Lack of available content:

Most people in rural areas prefer content in local or regional language. As per the vernacular report 2013 by IAMAI[14], 45 million users access content in their local language, which is 36.8% of the active internet users. With diverse cultural and linguistic landscape in India, it is very difficult to provide relevant content in local languages. India's broadband network needs to offer affordable content that is relevant to the country's diverse population characterized by multiple languages, varying levels of literacy, income and inequitable availability of physical infrastructure.

Limited affordability:

The PC penetration in India is limited to ~9 million rural households whereas ~14 million can afford computers as they are above the estimated affordability level of 0.5 million annual family income[15]. The investment for deploying and maintaining OFCs and 4G along with the

[13] Press Release IDC, August 2014. See: http://www.idc.com/getdoc.jsp?containerId=prIN25045514

[14] The Vernacular Report 2013 by IAMAI, Times of India, January 2014. See: http://timesofindia.indiatimes.com/home/The-Vernacular-Report-2013-by-IAMAI-Internet-and-Mobile-Association-of-India-showed-45-million-users-access-content-in-their-local-language-which--accounts-for-36-8-of-the-active-internet-users-in-the-country-122-million-December-2012-/articleshow/29661677.cms

[15] Reduce IT hardware cost to increase IT penetration: MAIT, October 2013. See: http://www.cxotoday.com/story/

increasing spectrum charges are responsible for high broadband tariffs. The FTTH connection will incur more cost to the network providers and ISPs, which in turn will end up in high tariffs. As India is a cost sensitive market, higher cost reduces the affordability making it difficult to increase the broadband coverage in rual parts of the country.

6. Connecting Rural Households to NOFN via fixed line

BharatNet was designed to provide scalable network infrastructure on a non-discriminatory basis, to ensure affordable broadband connectivity of 2 Mbps to 20 Mbps for all households. At the moment, fixed broadband penetration across the entire country is 1.4% (ITU, 2017). This low value is driven by a combination of supply factors (limited infrastructure to deliver fixed broadband), and demand factors (low income and the availability of substitutes such as mobile broadband). The intervention described here is to a) finalise the NOFN to connect GPs and b) facilitate accessibility to NOFN for rural households. These supply side actions should unlock latent demand for broadband in rural areas. Facilitating accessibility can be done in a number of ways, though perhaps the most feasible approach is to licence private enterprises to install and charge for household connections to NOFN. The government could consider subsidizing the cost for rural households.

Before describing costs and benefits, it is useful to describe the takeup of fixed broadband following the completion of NOFN. Demand for broadband, like any other good or service, is a function of income. Data on fixed broadband penetration and income were gathered for OECD and a selection of developing countries in 2015. The plot indicates a clear relationship between fixed broadband penetration and the log of income. It drives an equation:

$$Y = 12.8\ln(x) - 104.69$$

$$R^2 = 0.74929$$

This global, cross-sectional relationship is used to estimate growth of fixed broadband in Rajasthan.

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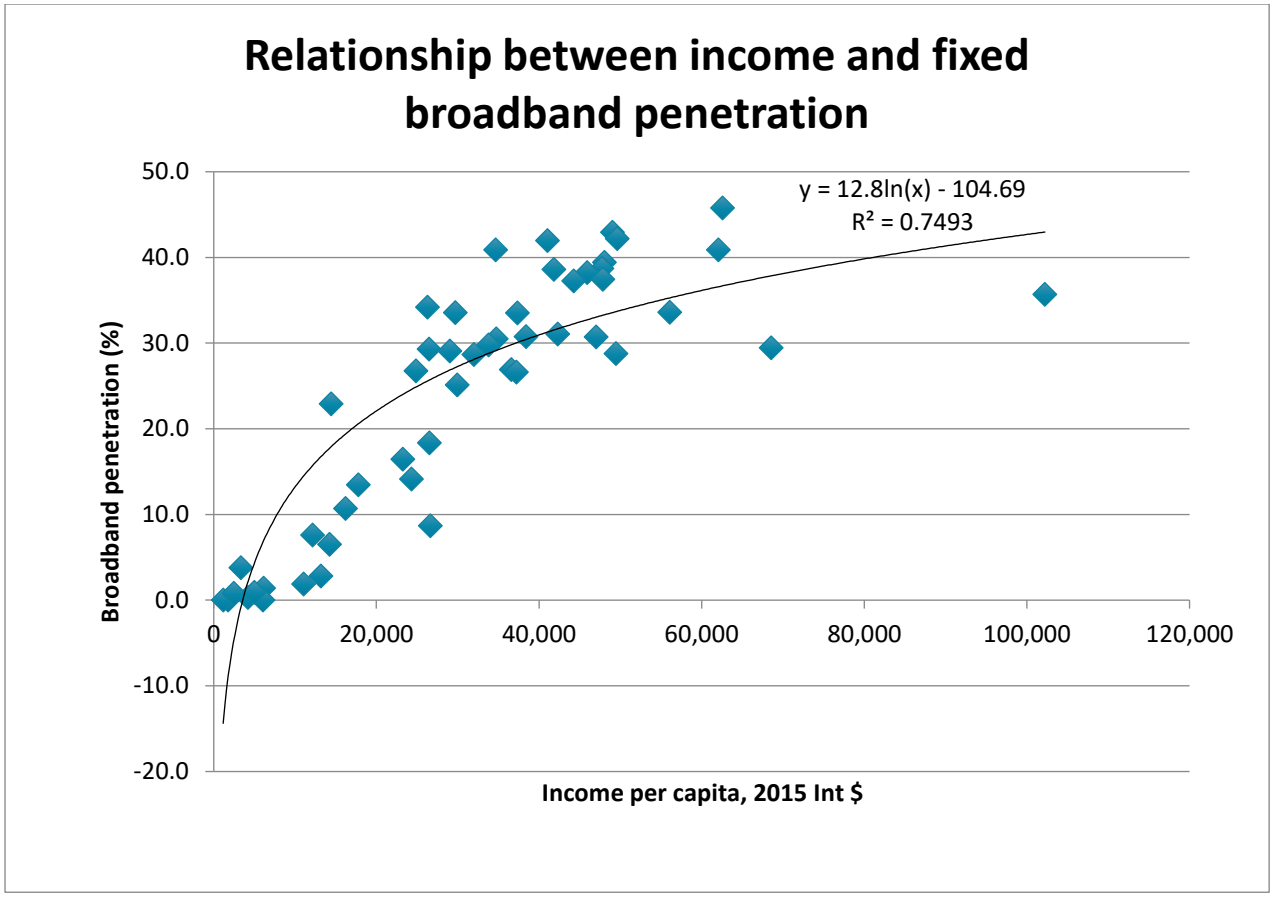
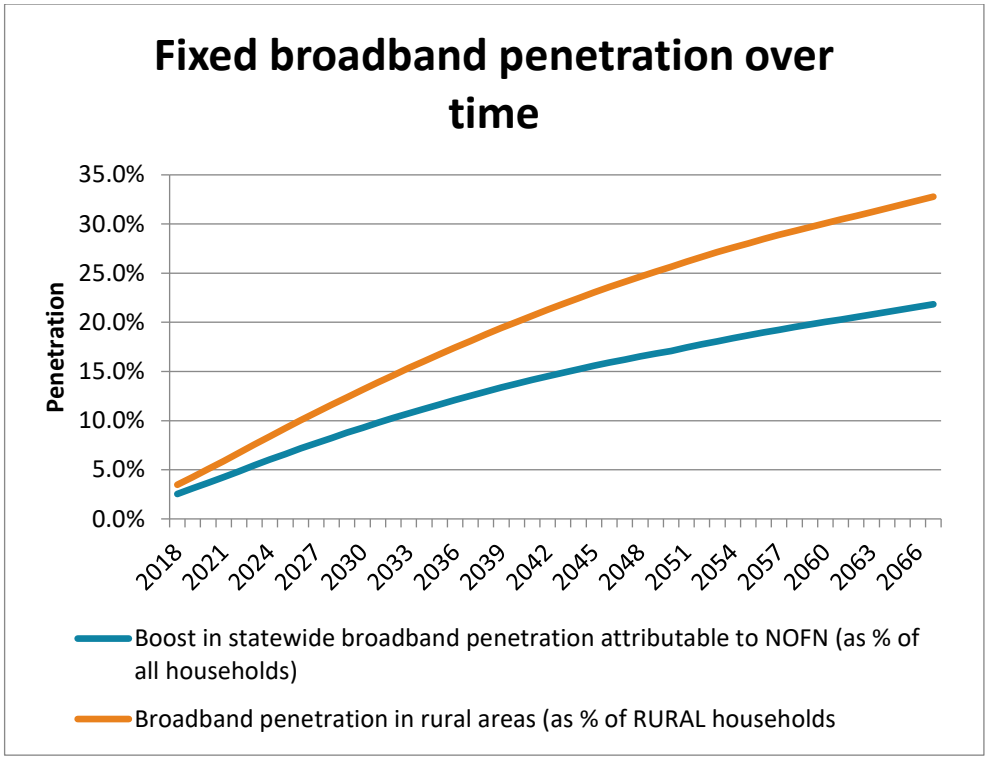
reduce-it-hardware-cost-by-43-to-increase-it-penetration-mait/



The NOFN is only delivered to rural areas, and so can only affect rural broadband penetration. To estimate uptake, we take the GSDP per capita projections provided by *Rajasthan Priorities* project as well as the population rural, urban split of 73:27. Following UNDESA (2018) we assume that urban population will increase by 23% by 2050, such that by the middle of the century Rajasthan will have a rural:urban split of 66:34. We further assume an urban-rural GDSP premium of 2. This allows us to calculate the approximate trajectory of rural penetration until 2067. By using the projected rural, urban splits we can also estimate the impact of NOFN on overall state-wide fixed broadband penetration. This is depicted in the figure below.



The results show that broadband penetration in rural Rajasthan will increase to 33 per 100 rural households by 2067. Due to the falling share of rural population in the state, this will contribute to a statewide increase in penetration of 22 per 100 households. It should be noted that this figure is *incremental* to broadband penetration arising from urban areas. However this marginal impact is sufficient for calculating benefits of broadband (see below).

Calculation of Costs and Benefits

Costs

There are four categories of cost associated with this intervention 1) cost of connecting the remaining GPs and ongoing maintenance; 2) cost to connect remaining households and ongoing maintenance; 3) upgrading the data centre cost to connect institutions (such as public health centre (PHC), schools, government agencies, etc) and 4) costs of accessing broadband services.

Cost of connecting from BHQ to GPs

The data shows that Rajasthan is steadily progressing in connecting its GPs through NOFN. As of writing, only 1745 GPs still need to be connected out of a total of 9,900[16]. It is assumed the remaining GPs will be connected over three years. The average cost of connecting a GP to the NOFN nationwide is 0.3 crore. Applying this cost figure to the remaining GPs and assuming they will be connected over three years, delivers a cost of 169 crore per year, for 2018, 2019 and 2020. The cost mostly covers the laying of fiber optic cable from the network to the GP.

Operating costs of the NOFN are assumed to be 0.015 crore per GP connected. This is based on a total cost of Rs. 3639 crore to cover 250,000 GPs across the country.

Cost of connecting GPs to Villages and then HH

There are 9,900 GPs and 44,672 villages in Rajasthan. Clearly not all villages will have a direct fixed line connection to NOFN. We first estimate costs to connect all non-GP villages to NOFN, and then households. The average kms to reach one village is 2.93 km; thus, the optical fibre cable (OFC) required to cover the remaining villages is 101,958 km. We apply a unit cost of Rs. 500,000 per km based on reports by NOFN.

It is assumed that once the OFC reaches the villages, it needs to be spread across the village (underground or over electricity lines) using an additional 1km of cable. This thick line will carry proper bandwidth required by all households. Based on estimates of 44,672 villages in the state, this implies 44,672 kms of line are required. We apply a unit cost of Rs. 400,000 per km based on reports by NOFN.

Lastly, thin OFC connections branching out of the household level line will be required for all homes that want broadband. We assume that 15 meters (about 50 feet) of OFC will be required to connect each household from thick OFC line running through the street/electricity pole or the existing telecom tower. This thin line has a unit cost of Rs. 50,000 per km. We include a cost of Rs. 1000 per household for a wifi-enabled modem.

The above calculations imply the cost of connecting one household using wired infrastructure is Rs. 7443. The operational cost for the last mile connectivity per household is assumed to be 5% of this cost, at INR 372.

[16] BBNL website; http://www.bbnl.nic.in/index1.aspx?lsid=577&lev=2&lid=471&langid=1; accessed on 14.5.2018

Cost of upgrading the data centre

In BharatNet, to connect the institutions at district, block and gram panchayat, data centres were established at the district level. These data centres offer variety of services like application hosting, server hosting and managed services in a secure environment for processing, storage and backup, networking, management and distribution of data (BBNL, 2015). As the NOFN will reach to the household level, the data centres need to be upgraded to ensure enhanced scalability to meet business growth. It is assumed that 8% of the total cost of data centre is required to upgrade the data centre every year to provide the connectivity at HH level. The cost of upgrading and maintaining the data cente will be INR 0.27 crore per year.

Costs of accessing broadband services

Recognizing the limitations of existing data, this intervention has used the data from the 68th round of the National Sample Survey to estimate the expenditure incurred by households on Internet services in 2011-12. This data comprises of the following components - laptop/telephone charges accruing to data; Internet expenses, device expenditure, and expenses on PC/laptop. The average per household expenditure incurred on the Internet using wold bank inflation rate is Rs. 300.

Total undiscounted costs of the intervention are presented below. The largest costs are for maintaining the NOFN itself, making up more than 60% of the total, undiscounted costs. Given the long time horizon, discounting is important. At a 5% discount rate the costs are Rs. 7,780 crore over 50 years.

Costs of connecting NOFN to households until 2067 (figures in 2016, Rs. Crore)

Cost of connecting remaining GPs	508
Cost of connecting HHs	2,673
Operations cost for NOFN including data center upgrades	16,242
Operations cost for HH connections	3,919
Costs of accessing broadband	3,159
Total (undiscounted)	**26,502**

Benefits of connecting households through NOFN on GDP

There are several studies that demonstrate a connection between GDP growth and broadband penetration. The World Bank estimates that 10 percent increase in broadband penetration will lead to 1.38 percent increase in GDP growth on average for low/middle income countries, which is higher than the impact of mobile penetration on GDP growth (KPMG & CII, 2013). Czernich et al (2011) using instrumental variable approach to control for endogeneity, identify a relationship of 0.9 – 1.5 percentage points (pp) increase in GDP for 10 percent increase in broadband penetration. Koutroumpis (2018) examining the impact of broadband on OECD countries, shows that increases in broadband adoption boosted GDP over a 15 year period by an average of 0.3% per annum. The relationship between broadband adoption and GDP boost was 1.4 pp for 10% increase in penetration. Finally Koutroumpis and Gruber (2011), analyzing the effect of mobile broadband, show a result of 1.1 pp increase in GDP growth for every 10 per cent increase in penetration. It should be noted that none of these papers are based on analysis of developing countries.

In this study we follow Koutroumpis (2018) as that represents the paper with the most recent evidence. Using the relationship from that paper we estimate the annual boosts to GSDP arising from the pathway of fixed broadband growth across the entire state attributable to the NOFN. After three years the boost to GSDP is small, measured at only 0.02%. By 2035 the boost is 0.1%, by 2050 the boost is 0.2%, and by 2067 it is 0.3%. Note that these GDP jumps *accumulate and compound*, such that small boosts to GDP have significant benefits over a 50-year period. The incremental boost to GSDP is Rs. 135 crore by 2020, Rs. 3,233 crore by 2035 and Rs. 27,299 crore by 2067. In GDSP per capita terms, the corresponding values are Rs. 8, 345 and 2,769. Total benefits until 2067 equal 81,552 crore at a 5% discount rate. The benefit-cost ratio (BCR) of the intervention is 10.

Summary BCR Table

Interventions	Discount Rate	Benefit (INR in crore)	Cost (INR in crore)	BCR	Quality of Evidence
Providing the NOFN connectivity from gram panchayat (GP) to household (HH) level using wired infrastructure	3%	156,022	11,878	13	Medium
	5%	81,552	7,780	10	Medium
	8%	34,455	4,763	7	Medium

Source: Author Calculations

It should be noted that the calculations have not considered the cost of 'Right of Way (RoW)' and other costs such as cost of coordination of multiple service providers across various segments after GP level and the cost of Point of Interconnects (PoIs) at the block level to deliver services in rural areas. There are significant risks in implementation of this intervention. Noted challenges include the complex regulatory mechanism, structural challenges in BBNL, functionality of service providers, low bandwidth for the last mile connectivity, lack of affordable devices and content available in rural regions (Deloitte, 2014). For these reasons the strength of evidence is labeled medium.

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Part 2

Cost Benefit Analysis of linking remaining MGNREGA beneficiaries to Aadhaar through positive reinforcement

Rajasthan Priorities
An India Consensus Prioritization Project

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Academic Abstract[1]

With a promise to provide 100 days of wage employment to at least one member of the estimated 150 million rural households across India, the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) is the largest rural employment guarantee program in the world. However, the program has come under the scanner for various implementation and service delivery issues since its inception. When the government rolled out the Aadhaar program, one of its stated aims was to streamline the implementation of all current and future anti-poverty programs. The Aadhaar system has already been established and implemented in various government schemes. This paper examines the major costs and benefits of linking the last group of unconnected MGNREGA workers to the Aadhaar scheme. The findings shows that although there is considerable cost involved in linking the remaining group of workers, the benefits are much higher. The calculations yield a positive benefit cost ratio, with benefits arising from reduced leakage and corruption.

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Policy Brief

Overview

Since independence, India has spent billions of dollars on social welfare schemes through a range of subsidies and an array of targeted poverty reduction programs. The government's total expenditure on state social welfare schemes has increased from Rs. 28,199 crore in 1990 to Rs. 8,99,157 crore in 2016 (Social sector expenditure of state 2014-2016, NITI Aayog). Among all key social welfare schemes initiated till date, the MGNREGA has been the largest. Targeted at covering 42 percent of India's total rural population[2] living below the poverty line, the scheme has grown many folds since with government budget expenditure increasing from Rs. 35,711 crore in 2012 to Rs. 45,303 in 2016[3]. Currently, the scheme has more than 2,555 lakh registered workers[4].

MGNREGA provides a legal guarantee of 100 days of employment in public works per year to at least one member each of all rural households. It has yielded positive effects on income generation for below-poverty-line households. Over the years, however, it has failed to live up to its full potential due to alleged corruption, logistical failures and administrative faults. Numerous cases of money being siphoned off via "ghost beneficiaries[5]" and duplicates[6] were identified as a source of massive monetary leakage. This set the scene for the government to combine information and communication technology (ICT) with various anti-poverty strategies for better implementation of schemes and reduction in leakages.

As the country's high rate of illiteracy makes it difficult to deploy traditional methods of authentication, the use of ICT-based biometric technology such as Aadhaar for unique identification has been seen as especially promising. Financial inclusion and social protection have provided the basis for using Aadhaar in social welfare payments. This paper aims to

[2] https://www.rbi.org.in/scripts/PublicationsView.aspx?id=16603 accessed on 9th May 2018
[3] source: Financial statements for the years 2012-13, 2013-14, 2014-15, 2015-16 and 2016-17 on the MGNREGA dashboard
Note: Data extracted on January 2, 2018
[3]http://mnregaweb4.nic.in/netnrega/app_issue.aspx?lflag=eng&fin_year=2017-2018&source=national&labels=labels&Digest=cT/J7ChEq5LOfEr0AmsuAQ accessed on 9th May 2018
[5] Ghost Beneficiaries: People who have either died or migrated to other villages, however their name and details still remain in the government record and these details are misused by middlemen to siphon off money.
[6] Duplicates: One person getting money twice

evaluate the benefits of linking those MGNREGA beneficiaries yet to be connected to the Aadhaar scheme. Since Rajasthan is one of the top national spenders and performers w.r.t. the employment generation program, it is pertinent to look at the benefit cost ratio of linking remaining MGNREGA workers to the Aadhaar scheme. Currently, there are 92 lakh active MGNREGA workers in Rajasthan, of which 86 lakh workers have an Aadhaar number they use with DBT[7].

Rajasthan embarked on the mass collection of biometric data for Aadhaar in 2013 along with other states. According to the government, the Aadhaar scheme has potential to enhance the effectiveness of India's social protection programs in three ways[8]. First, it will help curb cases of fraud and improve the delivery of government welfare programs. Second, it will help in plugging leakages in the system by removing duplicate transactions and middlemen. Finally, it will also reduce the delay in payment by integrating DBT with the beneficiaries' account.

Intervention: Linking the last section of the unconnected MGNREGA population to Aadhaar

Although 93 percent of all active MGNREGA beneficiaries have Aadhaar numbers and receive payments in their respective bank accounts[9], the remaining beneficiaries need to be allotted an Aadhaar number and have their accounts linked to the DBT scheme. This paper analyzes the involved costs and benefits of transitioning from cash payment of MGNREGA wages to payment via the beneficiaries' bank/post office accounts linked to Aadhaar.

This intervention targets the last seven percent of the population who are not linked to Aadhaar and DBT for year 2017-18. A multi-year projection model is built on the basis of recurring benefits for the next 15 years. This includes linking new workers to the scheme, training and back-end linking of cards, etc. The primary benefit is reduction in leakages.

The study proposes that the government should use positive reinforcement to link remaining beneficiaries to the Aadhaar-MGNREGA initiative. This can be done by providing incentives

[7] Direct Benefit Transfer- Direct Benefit Transfer or DBT is an attempt to change the mechanism of transferring subsidies launched by Government of India on 1 January 2013. This program aims to transfer subsidies directly to the people through their bank accounts.
[8] http://stateofaadhaar.in/wp-content/uploads/State-of-Aadhaar-Full-Report-2016-17-IDinsight.pdf

[9] Author's own calculations

such as early release of pending salaries to new Aadhaar enrollers and to those who link their Aadhaar cards to their bank accounts. During 2015-16, about 52 percent of all payments, i.e. Rs. 1,220 crore, was delayed by more than 15 days[10]. While the proposed intervention will not require any further spending by the government, this minor modification in the system would motivate workers to get an Aadhaar card.

Implementation Considerations

An increasing body of literature points to a positive relationship between access to formal financial services and economic prospects for poor individuals and communities. By bringing all MGNREGA workers under the fold of a formal institution via Aadhaar and MGNREGA seeding, it is estimated that the leakages in the scheme will be reduced by 41 percent. The total cost of the scheme is estimated to be Rs. 24 crore, with most of them incurred in the first year. While the Aadhaar initiative has faced severe criticism from several social scientists – primarily due to issues over the right to privacy and life (Khera, 2016) – a variety of problems related to failure of proper authentication due to malfunctioning biometric machines in the field and unavailability of adequate connectivity have also been highlighted (Khera, 2013; 2017).

The current analysis has been carried out on the basis that the Aadhaar scheme has been implemented at an expense of Rs. 8,800 crore and is currently in use. This paper is an attempt to understand if investing a little more in the existing system can help improve benefits accrued in the long term. It estimates the incremental costs and benefits of linking unconnected workers to the system. In this case, the primary benefit will be in reduced leakages caused by the incidences of ghost beneficiaries[11] and deception [12](Khera, 2011). MGNREGA was previously criticized for excessive corruption in wage discernment and evidence suggests up to 20 percent[13] of funds allocated under MGNREGA are lost to

[10] http://stateofaadhaar.in/wp-content/uploads/State-of-Aadhaar-Full-Report-2016-17-IDinsight.pdf pg
[11] Ghost cards : card existing and names of non-exiting/dead beneficiaries
[12] Deception: Deception is when middlemen open and operate bank accounts on behalf of the registered worker; they then withdraw inflated wages from the account; pays the worker his/her due and pocket's the inflated amount.
[13] Economic Survey of India 2017

leakages. The total savings accrued from reduced leakages through this intervention are estimated at an average of Rs. 14 crore per year over 15 years.

Cost and Benefit

Costs

There are three categories of costs associated with this intervention. The first is bringing the remaining one percent of workers or approximately one lakh beneficiaries, under the Aadhaar scheme. The cost per person for this is estimated at Rs. 315, including personal costs towards time and travel. The total cost of this component is Rs. 4.5 crore.

The second component of costs is linking new Aadhaar account-holders to DBT, so they receive payments directly in their bank accounts. The cost per person for this is Rs. 156. With 6 lakh workers requiring linkage to DBT, the cost of this component is estimated at Rs. 9.5 crore. The total one-off cost for this intervention is Rs. 14.6 crore.

The recurring costs towards procuring biometric devices, its maintenance and connectivity have been calculated on a yearly basis at Rs. 1.3 crore in the first year, projected downwards for likely counterfactual growth in Aadhaar enrolments. The total cost of the intervention is Rs. 24 crore over a period of 15 years at a 5 percent discount rate.

There are other real and perceived costs of expanding the Aadhaar system. Privacy has been stated as one of these major social costs in various literatures. However, the costs estimated in these deliberations are primarily individualistic and uncertain. This paper has not included potential privacy costs in this analysis and only notes that the benefits of this intervention represent a 'minimum hurdle' that privacy costs must exceed to render the intervention ineffective.

Benefits

Financial benefits accrued through Aadhaar from leakages plugged are discussed in this paper. Gains yielded from reduction in two types of leakages have been estimated a) leakages due to duplicity in the system b) leakages due to deception[14]. Leakages caused by

[14] Discussed in Khera 2016; leakages due to deceit takes place when middlemen open and operates account on behalf of laborers , they withdraw the inflated wages from the banks pay workers their due and pocket the remaining.

extortion by middlemen or collusions between workers and middlemen have not been included, as they remain unaffected by the Aadhaar system. Based on the experience of Muralidharan et al (2016), the paper estimates a 41 percent reduction in leakages and applies it to the share of wages earned by workers who are not yet fully within the biometric payments scheme. This benefit works out to be about Rs. 17 crore in the first year. There are two countervailing adjustments made to this number over the timeline of the analysis. First, real growth of MGNREGA wages is accounted for and assessed at 3.5 percent per annum based on recent experience. Rising MGNREGA payments increase the pool of potential money that can be corrupted, and hence boost benefits. Additionally, the analysis has also adjusted benefits downwards to reflect likely counterfactual growth in Aadhaar and DBT enrolments. The net effect is that average undiscounted benefits are Rs. 14 crore per year, with the total benefit over fifteen years amounting to Rs. 150 crore at a 5 percent discount rate.

Inculcation of the habit of saving amongst workers is a perceived social benefit of having a mandatory bank account. This will also give women workers more authority over their own income as they can choose to either save it in the bank or spend it. Earlier, while women workers saved at home, cases of husbands / other family members extorting this income were widespread. However, this particular benefit is not included in the current analysis.

The 12-digit Aadhaar number has now been made officially mandatory for accessing social welfare benefits in the country, although technically it is still not[15] (Ministry of Rural Development, 2017). The Aadhaar scheme can help improve access to other benefits such as enrolment for education (admission in government schools); healthcare, including pre-natal, neo-natal and post-natal care at hospitals; and access to food via public distribution systems (although numerous cases of leakages have been identified due to technological failure, connectivity issues and misclassification in the PDS system, when combined with Aadhaar). This benefit is also omitted from the current calculation.

The Benefit-to-Cost Ratio (BCR) of this intervention is 6 at a 5 percent discount rate.

[15] http://rural.nic.in/sites/default/files/DBT_letter_RegAadhaar_exception_handling19Dec17.pdf

Intervention	Costs (in Rs. crore)	Benefits (in Rs. crore)	BCR
Linking the last section of the unconnected MGNREGA population to Aadhaar	24	150	6

1. Introduction

India has spent billions of dollars on employment generation programs to combat the challenge of poverty. Targeted social welfare schemes in India take many forms and are administered through hundreds of central and state government programs such as Jawahar Gram Samridhi Yojana (JGSY), Integrated Rural Development Program (IRDP), etc. The MGNREGA, in particular, is a complex scheme with program components that involve a wide range of institutions and stakeholders, affecting a range of potential (intended and unintended) economic and social outcomes (3ieimpact, 2017). Rajasthan has been one of the top performers in implementing MGNREGA among the larger states in terms of total number of active workers (92.55 lakh as against an all-India average of 31.84 lakh in 2017–18) and also has an above-average participation rate of women (53.91 lakh as against 15.67 lakh for India in 2017–18). Currently, there are 92 lakh active workers employed under MGNREGA and 86 lakh of them have Aadhaar numbers. Thus, the total numbers of workers to be enrolled in Aadhaar are 6 lakh. According to official statistics, all of the 86 lakh active workers with Aadhaar have enabled DBT, resulting in direct credit of wages to their Aadhaar-linked bank or post office accounts.

This paper draws on the results from a large-scale cluster-randomized control trial on the effects of linking smart cards – a biometric precursor to Aadhaar - to MGNREGA payments in Andhra Pradesh. The Andhra Pradesh study had estimated that leakages declined by 41 percent post the reorganization of the payment system toward direct transfer and biometric card-linked payments. This led to an increase in MGNREGA beneficiaries' earnings by 24 percent, without augmenting the government budget (Murlidharan, Niehaus et al. 2016).

This paper attempts to calculate the costs and benefits derived from bringing the above section of unlinked MGNREGA workers under the Aadhaar-MGNREGA initiative through a cost benefit analysis. The costs of the intervention are estimated at Rs. 24 crore, and are expected to reap benefits in reduced leakages worth Rs. 17 crore in the first year alone. This benefit is assessed against the natural rate of Aadhaar enrolment in the absence of the intervention and is extrapolated over a fifteen-year period. The total benefits accrued are estimated at Rs. 150 crore at a 5 percent discount rate, yielding a benefit-to-cost ratio of 6. Given the large amounts spent on poverty reduction programs in India, this intervention provides a significant opportunity to reduce corruption and leakages.

2. India's tryst with poverty alleviation schemes

In the past, the central government used to implement poverty alleviation schemes only during national calamities such as famines, floods or droughts (3ie working paper 27, 2016). In the colonial period too, labor programs became popular as a means of famine relief. After the Maharashtra famine in 1972, the Employment Guarantee Scheme (EGS) was introduced in the state as a demand-driven, bottom-up employment scheme meant to provide rural dwellers with the legal right to demand work from the state. The pro-poor targeting of the EGS, although considered highly effective in the early years of the program, steadily worsened as the government raised the wage rate to meet minimum wages in 1988 (Gaiha 2000). As wages started increasing, even the non-poor started demanding work. Consequently, the budget soared, corruption seeped in and the actual poor were excluded from the scheme. In 1989, two major employment generation schemes were clubbed together to bring in a stable rural employment program. However, the scheme arguably had little impact on poverty, as it was not well-targeted (Neelakantan 1994).

The central government's Employment Assurance Scheme (EAS) was launched in 1993 and 1994. The scheme failed due to its top-down administrative structure and implementation which encouraged gross irregularities, resulting in the employment of only 5 percent of the targeted group. In 2001, the EAS was revised and repackaged into the Sampoorna Grameen Rozgar Yojana (SGRY); a unique feature of this scheme was that it paid half of the wages in food grains.

While the government has spearheaded a number of programs and claimed that the incidence of poverty declined from more than 50 percent in the 1950s to 26 percent in the late 1990s (NCAER, Working Paper 169), currently at least 32 percent Indians still live below the international poverty line.

For targeted rural development through productive engagement of the under-employed, surplus and unskilled labor force, the government of India initiated one of its most ambitious projects - the National Rural Employment Guarantee program (NREGA) - by the act of

parliament in 2005[16]. It was "*unlike any other wage employment programme in its scale, architecture and thrust bottom-up, people centered, demand-driven, self-selecting, rights-based design is distinct and unprecedented*" (NREGA operational guideline, 2013). The act provides for at least 100 days of guaranteed employment to every poor household in the country whose adult member volunteers to be a part of the program. The government is mandated to provide employment to all those who are willing to work. If the state, for any reason, is unable to provide 100 days of employment in a financial year, it is obliged to pay unemployment allowances at a prescribed rate. This self-targeting mechanism of beneficiary selection was expected to help overcome the problems of targeting, since a large percentage of poorest of the poor and marginalized sections of the rural people are expected to seek employment under the scheme. The act also incentivized the state to provide employment as 100 percent of the unskilled labor cost and 75 percent of the material cost for the program are borne by the center (Operational Guidelines, 2013). Although, there is widespread awareness about the scheme, especially after the first round of social audits were conducted (Aiyar & Samji, 2009), there is far less awareness among rural dwellers that it is their right to get employment on demand.

In spite of NREGA being a demand-driven open-to-all program, its outreach and coverage are low. Since its inception, massive corruption through leakages in the system and delay in payments have been criticized. It was observed that even after working for days and months, laborers did not get paid. Middlemen within the system siphoned off the money, thus depriving genuine beneficiaries. This failure to implement the program appropriately was to be attributed to widespread corruption, logistical failures and faulty administration.

Given the inefficiencies and historical weakness of Panchayati Raj institutions in the states, the central government made it mandatory in 2008 for wages to be paid directly to bank and post office accounts, instead of cash payments through the Panchayat. This led to a sharp reduction in corruption due to the middlemen's inability to siphon off money. NSSO data suggests that between 2007–08 and 2011–12, wage corruption declined from 44–58 percent to 22–32 percent (Imbert and Papp 2015) for the country as a whole. These administrative

[16] NREGA was renamed as Mahatma Gandhi National Rural Employment Guarantee program (MGNREGA) in 2009. The study has used the two terms interchangeably

botches set the tone for India to combine information and communication technology with anti-poverty interventions; through the Direct Benefit Transfer scheme, the government sought to provide economic security and protection from adverse shocks to India's poor. The Aadhaar scheme came into the picture in 2010 to resolve these problems; the aim behind introducing Aadhaar was to remove financial leakages in the form of identity duplications embedded in the system, through biometric authentication and fund transfer capabilities.

3. Aadhaar enabled Payment System (AePS)

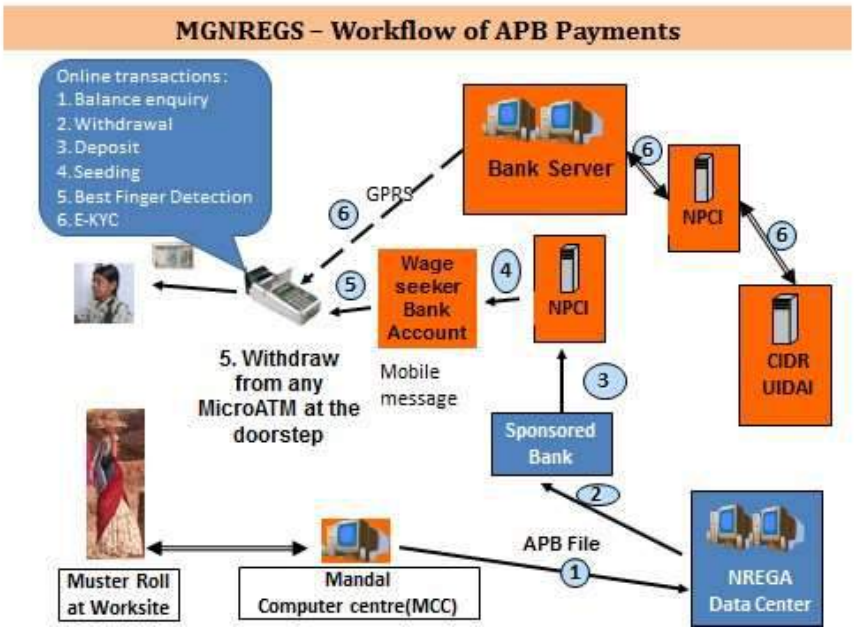
In areas where the penetration and network of banks and post offices is weak, the Project Implementation Agency (PIA) disburses wages in cash. This is mostly done only with prior intimation to the ministry and approval of the state governments, who are responsible for ensuring the requisite security for this purpose. If the PIA is not the Gram Panchayat (GP), the GP is held accountable for disbursement of cash payments. A payment committee is constituted, and all cash disbursements are made in the presence of this committee.

With an aim to reform the government service delivery system in various social welfare schemes, and reduce fraud and duplicity, the Indian government initiated the Direct Benefit Transfer scheme (DBT) in January 2013. In 2014, DBT was introduced in the MGNREGA scheme along with Aadhaar to facilitate wage payment. The program was an attempt to change the mechanism of transferring subsidies directly to the people. Its primary aim was to bring in transparency and terminate pilferage from distribution of funds disbursed by the central Government of India (DBT website, 2018).

Through the Aadhaar-enabled Payment System (AePS), MGNREGA payments are credited to beneficiaries' bank accounts using the job cards database and fund transfer orders from the NREGA server. The funds are then disbursed via micro ATMs through the wage seekers' AePS. Further, accounts are opened at their beneficiaries' doorstep under the e-KYC mode through micro ATMs (DBT website, 2018) for wage seekers who do not have bank accounts.

Currently, there are 86 lakh MGNREGA beneficiaries who avail DBT to get their wages directly into their bank accounts in Rajasthan. This accounts for 100 percent of the MGNREGA population for Rajasthan with Aadhaar (MIS MGNREGA, 2017-18). A pre-existing bank account, Aadhaar number and seeding of Aadhaar in beneficiary database and bank accounts

are the pre-requisites to avail benefits under the program. The system requires each Aadhaar number to be linked to one account (or joint account) in which the wages and all other benefits will be credited. The payment outlay is to be made through banking correspondents or Branch Post Offices based on biometric authentication using a biometric machine. The machine also enables the worker to access details of wage payments made and the amount standing to his/her credit by means of a mini-statement. All details of wage payments through bank/ post office accounts are recorded in the job card (MGNREGA operational guideline, 2013).



Source: DBT website, www.dbtbharat.gov.in

Rajasthan has seen a steady increase in the number of MGNREGA workers enrolled in the Aadhaar scheme; and the number has exponentially grown from 50.2 percent[17] in 2014-15 to 92 percent[18] in 2017-18. Getting paid directly to their respective Aadhaar-linked bank /post office accounts through direct benefit transfer would ensure no interference from middlemen, and reduce private transaction costs of travelling from village to the panchayat office. This will also help avoid the loss of a day's wage (if working elsewhere at that time) when beneficiaries have to travel to collect previous payment.

[15]http://mnregaweb4.nic.in/netnrega/state_html/UID_rpt.aspx?lflag=eng&fin_year=2014-2015&source=national&labels=labels&Digest=cT%2fJ7ChEq5LOfEr0AmsuAQ
[16]http://mnregaweb4.nic.in/netnrega/state_html/UID_rpt.aspx?lflag=eng&fin_year=2017-2018&source=national&labels=labels&Digest=cT%2fJ7ChEq5LOfEr0AmsuAQ

4. Linking the last section of the unconnected MGNREGA population to Aadhaar

Diversion of funds through ghost beneficiaries and inflated fake work records have marred the implementation of MGNREGA since its inception. In 2008, the government mandated the opening of bank accounts so wages could be directly transferred to the beneficiaries' accounts. Data collected from Rajasthan, among other states[19], has revealed a great deal of fraud related to fake job cards and improper maintenance of muster rolls (Chauhan et al., 2009). Using data from Economic Survey (2016-17), financial leakages due to duplicates and deception were calculated at 20 percent.

The government is currently enforcing Aadhaar as a tool to access government entitlements, intimidating people to link their Aadhaar cards by issuing threats of revoking social security entitlements (Aadhaar mandatory for MGNREGS work from April 2017[20]). The benefit and cost ratio calculated below finds that it is indeed beneficial for MGNREGA workers to get their Aadhaar number and link it with their bank accounts. This will result in costs of Rs. 24 crore and recurring benefits averaging 14 crore per year over fifteen years. Benefits are based on gains from plugged leakages and do not account for any other social benefits.

This paper suggests the government should resort to positive reinforcement to persuade the remaining group to get their individual Aadhaar number and then link it to their bank accounts. A potential cost-neutral option in this regard would be expeditious clearance of previous month's MGNREGA wage arrears for those who get a new Aadhaar card linked to their bank account. This could be reserved for new Aadhaar enrollees and could be time-limited to for example, one year. This move could become a stimulus in motivating those who do not have an Aadhaar to get one, especially for target beneficiaries who live a hand-to-mouth existence. This intervention will not create a dent on the already-budgeted MGNREGA funds; however, it will require a preferential payment option to be included in the scheme. To put this in perspective, it may be mentioned that for the current financial year 2017-18, there are 2,96,444 muster rolls due for payment (MGNREGA MIS, 2018).

[19] Bihar, Gujarat, Madhya Pradesh, Rajasthan, Tamil Nadu , Uttar Pradesh and West Bengal

[20] //economictimes.indiatimes.com/articleshow/56402579.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst.

Positive reinforcement techniques have worked previously in the Indian policy implementation scenario, as was seen in the case of Sarva Shiksha Abhiyan. The government started the mid-day meal scheme in 1995 to decrease school drop-out rates and increase the rate of enrollment (especially of the girl child). Under this program, a child who attends government-assisted primary schools would be entitled to a prepared mid-day meal with a minimum content of 300 calories and 8–12 grams of protein each day of school for a minimum of 200 days. This attracted children from disadvantaged sections (girls, Dalits and children from scheduled tribes). Additionally, the percentage of children in the age group of 6-14 years who are not enrolled in school has dropped from 6.6 percent in 2005 to 3.5 percent in 2010 in rural India. The proportion of girls in the age group of 11-14 years who were out of school also declined from 11.2 percent in 2005 to 5.9 percent in 2010 (Planning Commission's Approach Paper 2012-17).

5. Calculation of Costs and Benefits

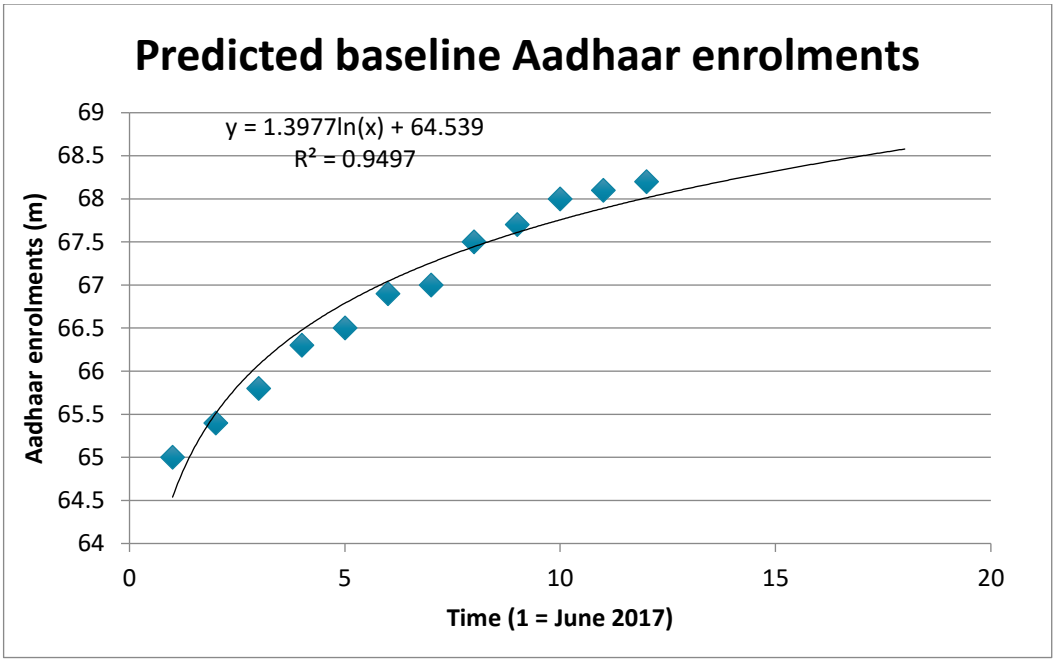
Baseline

Both costs and benefits are assessed against the predicted increase in Aadhaar enrolments in the absence of the intervention. At the time of writing this paper, 68.2 million Aadhaar cards had been issued against a total population of 75 million. This suggests 91 percent of the population have Aadhaar cards. Monthly data for Aadhaar enrolments is only available from June 2017 to May 2018 (UDAI website). Given that state and nation-wise rollouts are towards the tail end of the process, it seems reasonable to model the remaining uptake as a log function.

Monthly data is regressed against natural log of time, where 1 = June 2017, 2 = July 2017 etc.... The function form and coefficients are depicted below.

$$\text{Equation: } y = 1.3977\ln(x) + 64.539$$

$$R^2 = 0.9495$$



This function is used to predict baseline Aadhaar enrolments for 15 years, against which recurring costs and benefits are assessed. It is assumed that the intervention would result in complete linking of all MGNREGA workers to the Aadhaar system.

Cost

There are three categories of costs associated with this intervention: i) enrolling MGNREGA workers into Aadhaar and ii) ensuring those with new Aadhaar cards enable DBT payments and iii) reoccurring costs of biometric devices and maintenance, and connectivity for the newly-enrolled members. It is to be noted that these costs are assumed to have been incurred within the existing biometric direct payments system, already established for MGNREGA. Hence, much of the capital costs have already been incurred, and only a representative proportion of ongoing costs have been attributed to this intervention.

Cost of enrolling new MGNREGA workers to Aadhaar

For a NREGA worker to get a new Aadhaar card, he/she will have to travel to the enrollment center. This will result in a personal cost of a) Rs. 192[21] in lost wages while going to the center for enrollment and b) Rs. 50 for cost of commuting to the center. There will also be a public cost to the government. This cost is calculated from the UIDAI budget sheet (2018). The total

[21] Minimum wage for Rajasthan 2017-18 prices

expenditure for 2012-17 was Rs. 8,800 crore; this was divided by the total number of registered users 1,209,541,111 to arrive at the per-person cost. The per-person cost of getting an Aadhaar is estimated at Rs. 73 in government costs and Rs. 242 in personal costs for a total unit cost of Rs. 315. This cost is then multiplied with the total number of workers to be added to the scheme for Rajasthan, which is 6 lakh. The calculations yield a total one-off cost of Rs. 4.5 crore.

Cost of seeding: linking new and old Aadhaar number to NREGA

Seeding is a process to remove duplicates and fraudulent cards by linking the individual's Aadhaar number to the beneficiary lists of various government programs, such as an employment guarantee scheme in this case. This process requires the beneficiary to go to his / her bank. The cost of seeding is calculated by multiplying the individual personal cost incurred by the consumer to the total active MNREGS workers to be given DBT (to be linked to bank accounts i.e. 6 lakh workers). The personal/private transaction cost of traveling to the center and loss of half a day's wage is accounted for in the same (Rs. 156). The calculations have estimated a total one-off cost of Rs. 9.5 crore. Unit costs for the components above are presented in the table below.

Cost of Aadhaar	Estimated cost in Rajasthan
Direct cost per person to govt	
Total budget for country (in Rs. crore)	8,794
Number of people registered	1,209,541,111
Direct cost per person to govt	**73**
Cost application	(Rs. per person)
Cost of time (1 x daily wage)	192
Cost of travel	50
Total cost	**315**
Cost of seeding	(Rs. per person)
Direct Cost	10
Cost of time (half day)	96
Cost of travel	50
Cost of seeding	**156**

Source: Author's calculation

Reoccurring cost of Devices

Biometric devices are required to run the payment systems and the addition of 6 lakh workers to the payment system will lead to extra recurring costs. The costs of adding new devices and maintaining the old ones have been calculated assuming that the working life of machines is three years. The number of devices needed is estimated based on the assumption that each village will have at least one biometric machine. There are 43,264 villages in Rajasthan as of May 2018. Assuming that 1/3rd of the machines will need to be changed every year, the total number of biometric devices purchased by the state are estimated at 14,421.

Assumptions for the calculations are presented in the table below. Each device is assumed to cost Rs. 12,255, with maintenance charges running into Rs. 500 per year. The connectivity cost has been calculated at a rate of Rs. 1,788 per year. The model attributes 6 / 92 = 7% of the ongoing replacement, maintenance and connection costs to the intervention. This represents the proportion of new recipients under the Aadhaar-based payment schemes relative to the total. The reoccurring cost of the intervention is thus estimated at Rs. 1.3 crore in the first year, while declining against counterfactual assessment thereafter.

Cost of Devices	
Total biometric devices purchased by the state in last one year	14,421
Biometric Device Cost (Rs./device)	12,255
Biometric Maintenance cost (Rs. Per device per year)	500
Connectivity Cost (Rs. per device per year)	1,788
Total device cost (Rs crore/year)	1.3

Thus, the total cost of linking the remaining NREGA workers to the Aadhaar- NREGA initiative is Rs. 24 crore over 15 years.

6. Benefit of curbing leakage

The benefits of this intervention rest upon the work of Muralidharan, Neilhaus and Sukhtankar (2016). That paper assessed the effects of a large-scale randomized rollout of linking smart cards, the predecessor to Aadhaar in Andhra Pradesh, to the payment of NREGA wages. The results of that study showed that beneficiary households earned 24 percent

more, spent 20 percent less time collecting payments and received payments 6-10 days sooner than the control households. The estimated leakage reduction was 41 percent. The impressive results of the study are strengthened by the fact that the experiment was large, including 157 sub-districts and affecting 19 million people, and implemented by the government machinery of the state in question. This provides very robust evidence that similar effects are likely to replicate at scale, a common concern with randomized controlled trials typically conducted with relatively small sample sizes and by NGOs. Although the study was conducted in Andhra Pradesh, this paper uses these figures for Rajasthan's calculations too.

For the purpose of the current analysis, this paper focuses only on benefits accrued from plugging leakages. This is because the paper by Muralidharan, Neilhaus and Sukhtankar (2016) identifies that time-savings and payment processing benefits were likely due to the re-organization of the payments system from government agents across state, district and mandal levels to banks and local customer service providers hired to execute payments at the last mile. Given that this part of the reorganization has already occurred, and affects even those who are not linked to Aadhaar, these benefits cannot be claimed from the intervention suggested.

However, it is clear that the biometric and direct nature of the payment system is responsible for leakage reduction. This intervention addresses two types of leakages: leakage due to duplication and leakage due to deception. MGNREGA was mostly criticized for poor implementation, and lack of accountability and transparency in the system that led widespread corruption. In order to make best use of the resources, optimize the welfare program and to bring in fairness and transparency in wage payments, it was decided that the wage disbursement agency should be different from the agency implementing wage payments. Thus, it became mandatory for payments to be made through individual or joint savings accounts of workers, unless exempted. However, to ensure greater financial inclusion and to increase the outreach of the banking sector, the Reserve Bank of India had permitted banks to use intermediaries as banking correspondents (BCs) for banking business at places other than the bank premises.

The benefits assessed through this model presumes that most of the MGNREGA workers must have bank / post office / BC accounts and thus focuses only on those workers who are not yet linked to the DBT scheme.

As seen in the below table, total wage expenditure is the sum of the actual expenditure and payment due on unskilled wages at Rs. 3,351 crore. The percentage of leakages as per Economic Survey 2016-17 is 20 percent, and expected reduction in leakages due to Aadhaar-enabled DBT (reduction in duplication and deceit) is 41 percent (Murlidharan, Neihaus et al, 2016) of 20 percent. Thus, the gains from reduced leakages for total active MNREGS workers to be provided DBT are estimated to be Rs. 17 crore in the first year.

There are two counter-vailing adjustments made to this number over the timeline of the analysis. First, the real growth of MGNREGA wages is assessed, and is estimated at 3.5 percent per annum, based on recent experience. Rising MGNREGA payments increase the pool of potential money that can be corrupted, and hence boost benefits. Additionally, the benefits have been adjusted downwards to reflect likely counterfactual growth in Aadhaar and DBT enrolments. The net effect is that average undiscounted benefits are Rs. 14 crore per year, with the total benefit over fifteen years amounting to Rs. 150 crore at a 5 percent discount rate.

Benefits of reduction in MGNREGA leakage in Rajasthan	
Total wage expenditure (2015-16) (in Rs. Crore)	3,351
Percent of leakage in MGNREGA (2016-17)	20%
Expected reduction in leakage due to Aadhaar enabled DBT	41%
Benefits of reduced leakage in the first year (in Rs. crore)	17

Source: Author's calculations

7. BCR Table

Summary Table

Interventions	Benefit (Rs.)	Cost (Rs.)	BCR	Quality of Evidence
Linking remaining MGNREGA workers with Aadhaar	150 crore	24 crore	6	Strong

Notes: All figures assume a 5% discount rate

8. Conclusion

The proposed intervention to link remaining MGNREGA workers with Aadhaar through positive reinforcement is seen as measure to make optimal use of public money already invested in the Aadhaar framework. Although the derived BCR ratio of 6 is a positive indication towards adoption of Aadhaar, there is still a need to do a cross-sectional analysis of the Aadhaar framework to understand its complexities.

There is also an urgent need to improve the monitoring and implementation system as Aadhaar as a number will not be able to solve most of the existing issues in the system. These include leakages due to corruption, inefficiencies in the system and other technical issues associated with biometric authentication failure.

There are several unaccounted costs and benefits in this analysis, of which two require further mention. Privacy advocates have raised concerns about Aadhaar, citing for example, discomfort over the government holding a large database of citizen information that could be hacked or exploited for nefarious reasons. This is a legitimate concern, though the estimation of this cost is beyond the scope of this paper. The current benefits represent a minimum hurdle over which privacy costs must jump to render the intervention ineffective.

Another aspect that has been omitted is the general-equilibrium effects of the intervention. A working paper by Muralidharan, Neihaus and Sukhtankar (2018) suggests that the aforementioned smart card analysis had significant spillover effects to non-treated regions. Hence the benefits calculated in this paper have been underestimated to the extent that this intervention would also lead to spillover benefits.

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