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Ashima Goyal

Indira Gandhi Institute of Development Research, Mumbai
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Ashima Goyal

Indira Gandhi Institute of Development Research (IGIDR)

General Arun Kumar Vaidya Marg

Goregaon (E), Mumbai- 400065, INDIA

Email (corresponding author): ashima@igidr.ac.in

Abstract

The paper explores the contribution of innovations to Indian growth. Inclusive innovations aid catch-up and close productivity gaps. An analytical framework helps to characterize policies that contribute to such innovations. Recent telecommunication and mobile banking policies are assessed against these. While policy can directly encourage it, if innovation depends on market size above a threshold, policies that expand size can be more effective in inducing innovation. While policy successfully expanded mobile use, increasing revenue has recently taken precedence over expanding the market. Poor provision of the relevant infrastructure continues to exclude sections of the population and limit spillovers. Regulatory measures that limited market size were partly responsible for India's lack of success in mobile banking, compared to Pakistan

Keywords: Inclusive innovation, technology policy, telecom, mobile banking

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Growth drivers: ICT and Inclusive Innovations

1. Introduction

The paper explores the potential contribution of innovations to growth. Innovations are essential to raise productivity and enable sustained growth. Moreover, applications of Internet and mobile communication technologies (ICT) are suited to both growth and inclusion. Inclusive growth is a major Indian objective. The two can go together if inclusion is of the type that facilitates growth. 'Active inclusion' is defined as creating conditions for the many to contribute to and participate in growth (Goyal 2012). ICT helped India catch the outsourcing wave but this largely created opportunities for a skilled elite. One reason was poor governance and delivery of public services such as health, education and infrastructure handicap the less well-off who cannot afford private substitutes for these services. But ICT can itself reduce the cost of some of these public services. E-delivery can improve transparency and governance as it reduces discretion and corruption. A technology-based strategy of inclusion is uniquely suited to Indian catch-up growth and youthful demographics, since it increases rewards to work, while redistributive strategies are suited to persistent poverty.

The mobile is an example of a technology product whose falling costs made it accessible to all income classes. Mobile telephony has been one of India's success stories demonstrating the potential of ICT for inclusion. The growth of the Indian communication sector was in double digits after 2000 and its annual contribution to GDP growth around ten present. According to the regulator, India moved from just 5 million telephone subscribers in 1991 to 37 million in 2001 and 898.02 million in 2013. Mobile cellular subscriptions per 100 at 72 in 2011 compared well with the US figure of 93. But still the mobile's contribution has fallen far short of potential in terms of availability of mobile enabled services. For example, many other Emerging and Developing Economies (EDEs) have had greater success with mobile banking.

An inclusive innovation is one which creates products that can be accessed by all classes, improving their productivity, and are not restricted to the elite. The paper develops a simple analytical framework that clarifies the conditions that foster inclusive innovation in EDEs. It brings out two ways of facilitating inclusion through innovation: First, induce more technical change in products consumed by the less well of thus lowering its costs for them and second, to make more of capital available to the less well off, thus charging the slope of their budget line. Alternative ways of doing this are through income transfers or through better public provision of the relevant infrastructure. The latter is suited to active inclusion.

The paper next assesses India's telecommunication policy (2012) and policy changes towards mobile banking to examine the extent to which they have improved relevant infrastructure such as broadband, or taken steps to increase market size. Policy statements have normally emphasized inclusion but implementation has been lacking. Since a rise in market size strengthens private incentives for inclusive innovation it is likely to improve outcomes[1]. Comparing regulations and outcomes in India with other EDEs, especially Pakistan, clearly illustrates. Comparison with Pakistan is particularly apt since they are neighbouring countries with India generally outperforming on most economic criteria. Both introduced mobile banking in 2008 but Pakistan has far overtaken India in this area. The case study shows flexibilities in Pakistani policies encouraged market size, while India paid inadequate attention to user convenience and to factors driving innovation, thus limiting potential market size.

New technologies have the potential to raise opportunities for the middle, and create greater domestic inclusion, with appropriate policies. But assessing Indian technology policies on these yardsticks shows they have fallen far short. Better coordination mechanisms and incentives envisaged in recent policies may aid implementation, which is critical since the use of such technologies may have reached a critical threshold. Further innovation in an enabling environment can make substantial contributions to Indian growth. Increasing the market size creates broader incentives for innovation and reduces the need for direct government inputs that have been difficult to provide.

Gorden (2012) divides innovations in advanced economies such as US and UK into three periods. While 1750 to 1830 was the period of steam and railroads; from 1870 to 1900 electricity, motors, plumbing, water supply, telephone, chemicals, petroleum contributed;

[1] Manoj Pant pointed out Governments can rarely be relied on to achieve results. But although government failures are frequent so are market failures. That is why policies that work through improving private incentives could to be more effective.

and1960 onwards is the period of ICT. We label the three technology regimes Mark I, Mark II and Mark III respectively. He argues Mark II was the most important and was the major contributor to rapid 20th century productivity growth. In his view, ICT created only a short growth burst between 1996 and 2004 and is unlikely to create further growth.

In India even the spin-offs from Mark II inventions such as urbanization, good transport, water on tap, sanitation, and the release of household time are far from complete. Many of these have to come in the form of better public services. While the well-off can compensate for failures in the latter, the less well-off cannot.

Analysis shows large market size stimulates innovation to profit from it, since adoption and further adaptation of technology responds to economic incentives. If public services that more widely apply technology Mark II expand the size of the middle class, and induce more innovation in technology Mark III, that itself can create more inclusion. While private innovation generally favours the better-off, ICT has more potential for innovation for the middle-and lower middle classes, which improves inclusion. Thus improving public services can trigger more innovation in ICT, generating rapid inclusive growth. Goyal (2005) analyzes some of the associated virtuous cycles. ICT that substitutes electronic for physical transactions reduces transaction costs and speed of market access, thus compensating for other constraints. It lowers the cost of entry for a new firm, and raises productivity. Finally, it encourages cumulative improvements in technology and skills, inducing more labour-using technological progress (TP).

Technology imports play a major role in catch-up growth. In past such episodes, technology was biased towards using capital—for example, in the US catch-up years of the early to mid-nineteenth century and for the early period of Japanese industrialization. The capital-output ratio rose and the contribution of total factor productivity (TFP) to growth in labour productivity was less than that of the growth in capital-labour ratio. The Kuznets's stylized fact of capital-output ratios that fell as TFP rose emerged only after 1890 when maturity was reached (Hayami, 1998). This was so even in Asia where labour was naturally more abundant, perhaps because the Western technology imitated was capital intensive. TFP's contribution to labour productivity growth in the Asian economies was less than half its contribution in developed economies. It is possible ICT based innovations in populous EDEs, currently in the catch-up phase, can have a medium- rather than a high-skill or capital-bias after they reach a critical threshold if supported by appropriate policy action. The analysis helps identify some of the latter.

But it is widely perceived that ICT has the opposite effect. It is regarded as only helping those with skills, leading to a ‘winner takes all’ outcome. The best drives out the average. Technology companies such as Microsoft, Facebook and Google become globally dominant and earn huge amounts. In advanced economies (AEs) inequality rose with higher rewards to exceptional skills. Cecchini and Scott (2003) show how, in the EDE context, more TP tends to occur at the higher end and widens the digital divide. In 2009 Indian finance, insurance and real estate sectors had the highest labour productivity but employed less than 2 present of the labour force (Hasan et. al. 2012).

Nevertheless, Mark III technologies reduce inequalities between nations, by creating a virtual labour market and making information more easily available. Subramanian (2013) points out that post 2000 (the Mark III period) cross-country inequality reduced since about 80 EDEs grew faster than AEs. Pre-2000 only about 20 EDEs managed this feat. The potential contribution of ICT to development was recognized early. The World Bank has many reports on this topic. Avgerou (1998) offers an early analysis. Jorgensen (2001) and OECD (2001) assess ICT’s contribution to productivity improvement in AEs, which should also happen in EDEs.

Goyal (2007) illustrates the expansion of the middle in the rise of employment of and wages to intermediate skills when new technologies, which make it possible to employ distant labour, allow an AE with high and medium-skilled labour to interact with an EDE with medium and low-skilled labour. If the elasticity of substitution between labour inputs is high, expansion in labour supply induces medium-skill biased technical change, which raises the demand for such labour. As a result, inequalities tend to fall in the AE, skill premiums rise marginally in the EDE, but equality improves because labour employed in the low-skilled sector shrinks, and average wages also rise.

A concept of household production technology (Goyal 2011) shows why ICT has the potential to increase the equity and efficiency of female participation in the labor force. It helps restore flexibility in female external labor supply since it facilitates distance work, flexi-time and location activity, making it easier to match skill to jobs, and to maintain and upgrade skills. But complementary policies are essential. Entrenched social structures and perceptions have also to be changed.

The structure of the paper is as follows: Section 2 presents the analytical framework, which is used to assess ICT and technology policy in section 3; section 4 similarly analyzes mobile banking, before section 5 concludes.

2. An analytical framework

Consider an economy whose ICT sector has three techniques, and their convex combinations, available at any period of time. The first A is more skill and capital intensive, B is intermediate, and C can be produced with low skills. These generate the segmented production isoquant P_1 in Figure 1 in the H and O input space. H denotes high quality inputs including skills and capital, while O denotes 'ordinary' or low skilled labour inputs. The economy also has two groups of consumers, the well-off (W) whose endowment has more capital compared to labour, so that the budget set facing them has slope WW, and the less well-off (L) with more labour compared to capital and a trade-off between the two inputs given by the slope of LL[2]. The W group chooses technique A while L can only afford technique C.

In period 2, technology improves so the isoquant shifts downwards. There is no improvement in the low level technology C. Indeed, development requires moving away from the use of C. In Figure 1 both B and A improve to B_1 and A_1. Since the W group can shift to a lower budget line and improve welfare by using technology A_1 compared to B_1, they prefer to use A_1. Technique A becomes obsolete. As long as the slope of B_1C exceeds that of LL, C continues to be the welfare maximizing or expenditure minimizing technology for the L group, since the rate at which group L can substitute H for O to reach B_1, given their budget constraint, is lower than that required in the technology of production—the marginal rate of substitution is less than the marginal rate of transformation. In the new equilibria, the welfare of group W improves and that of group L is unchanged. The digital divide, or distance between the W and L groups, widens. The economy remains in a low level trap[3].

[2] The endowment inequality is severe enough so that trade between the agents cannot reduce inequality. Thus the market imperfection is persistent to possible resolution from market action. I thank Uday Bhanu Sinha for this point.

[3] Cecchini and Scott (2003) use this framework to show how technology can favour the elite, and widen disparities.

Place Figures 1 and 2 about here

In Figure 2 techniques A and B improve to A_2 and B_2 respectively, but the improvement is relatively more now in the intermediate technology. If the slope B_2C is equal to or less than LL, the L group shifts from using technique C to using B_2. If slope B_2A_2 exceeds WW the group W can also raise welfare by shifting to technique B_2 from technique A, since the marginal rate of substitution in technology exceeds that on their budget line.

This is a simplified model. In reality there will be product differentiation even among intermediate techniques with the W group choosing higher-end more feature rich products.

Even so, the model has interesting implications for policy. There are two ways to shift group L to the better technology B, thus improving their prospects. One is to induce more technical change in B, thus lowering its costs for the group L and making it accessible. The second is to make more of capital available to group L, thus steepening the slope of their budget line. This could be done through income transfers or through better public provision of the relevant infrastructure, since group L finds it more difficult to compensate privately for poor public infrastructure. For example, poor business services favour big business since small business is more dependent on public services.

What affects the rate of technological change? In order to answer this question we develop a more formal model, without an arbitrary restriction on the number of techniques, in which to explore the drivers of technological change. If increasing the scale of use of the intermediate technology induces TP, then the second way to shift L would support the first also, as it induces inclusive TP.

2.1 A formal model

Consider an economy in which aggregate output is produced by a combination of two worker-types: first with high (H) and second with intermediate or low skills (O)[4]. A large number of techniques allow smooth substitution between the two inputs, so the aggregate production function can be written in the constant elasticity of substitution (CES) form, where $\rho \leq 1$. The A terms denote factor augmenting technology.

[4] This section adapts part of the model in Goyal (2007).

$$Y(t) = \left[(A_0(t)O(t))^{\rho} + (A_h(t)H(t))^{\rho} \right]^{1/\rho} \tag{1}$$

The intermediate-skilled, O(t), and high-skilled, H(t) workers are risk neutral and maximize the discounted present value of labour income in competitive labour markets. The elasticity of substitution between the two inputs is $\sigma \equiv 1/(1-\rho)$. The two-worker types are gross substitutes if $\sigma > 1$ (that is, $\rho > 0$). Empirical estimates for the elasticity of substitution between more and less educated labour give a range between 1 and 2 (Freeman (1986), pp. 366)[5].

The simplest interpretation, without loss of generality, for the aggregate production function (1) is that of a two-good economy, with each good produced by one type of worker and aggregated by consumer preferences over the two goods[6]. Dropping time subscripts, the production functions for the two goods then are:

$$Y_h = A_h H \tag{2}$$

$$Y_O = A_0 O$$

The consumers' utility function is defined over the two goods is:

$$\left[Y_o^{\rho} + Y_h^{\rho} \right]^{1/\rho} \tag{3}$$

2.1 Endogenous technical change

We assume firms in the two sectors choose between specialized ICT machines or processes, which raise the productivity of H or O worker-types, on the basis of relative profitability. For a simple analysis of endogenous choice of technique, let N_h and N_O be the number of specialized machines for high and intermediate-skilled workers respectively. The sectoral production functions then become $Y_h = N_h H$ and $Y_O = N_O O$ where $A_h = N_h$ and $A_o = N_o$ so that the production functions are equivalent to (2)[7].

Under competitive conditions, consumers' maximization of utility (3), subject to a budget constraint, results in a standard relative demand function for the two goods. Inverting this

[5] Goyal (2007) shows, with a high elasticity of substitution, a rise in A_O relative to A_h will increase demand for intermediate-skilled workers.

[6] It can also be interpreted as the production function for a multi-good economy where different sectors employ both O and H worker types and produce goods that are imperfect substitutes.

[7] Our simple linear technology can be derived, as is common in the endogenous growth literature, from a more complex model with a continuum of firms and machines. At the firm level, the technology parameter A depends on the continuum of machines adopted. Decreasing returns for each firm gives a tractable solution to the firm's problem, even with constant returns at the aggregate sectoral level. Decreasing returns to R&D effort for each sector can also be considered as in Acemoglu (1998).

demand function, and substituting the production functions in it, gives the relative price of the skill intensive good:

$$p = \frac{p_h}{p_o} = \left[\frac{N_h H}{N_o O}\right]^{\rho-1} \tag{4}$$

The marginal willingness to pay for an additional machine is the marginal increase in profit due to a new machine. In each sector, this is the derivative of p_hY_h and p_oY_o with respect to N_h and N_o, that is, p_hH and p_oO respectively.

Schmookler (1966) and the endogenous growth literature have analysed how demand-pull and market size is important for the development of technology since the latter responds to profit motives. For example, as long as horses were commonly used, there was a high rate of innovation in horseshoes. Technology is exogenous in the sense basic research and major technical inventions occur before they are really used, but adoption and further adaptation responds to economic incentives. So, advances in basic science maybe independent of profit motives, but "micro inventions", or applications that follow, are often not so independent (Acemoglu 2002 pp. 31-38). Diamond (1997) also emphasizes relative economic advantage of new over existing technology as a strong influence on acceptance of innovations. Social factors such as the prestige of a new technology, the ease with which its advantages can be observed, and its compatibility with vested interests also play a role.

Now introduce innovators that create the machines. To bring out the basic issue in the simplest possible manner we assume *C*, measured in units of final output *Y*, is the fixed cost of creating a new machine. The marginal cost of producing a machine once it is created is zero. The creation of new machines continues for both sectors until the marginal increase in profit equals the fixed cost of innovation[8]. It follows that in equilibrium:

$$p_h\, H = p_o\, O \tag{5}$$

Thus two effects that stimulate the creation of new technologies are the price and market size effects. The price of the good using a more expensive factor will be higher from equation (4). But the market size effect encourages innovation for the more abundant factor, since a larger scale of use would generate profits. The rise in the market size for techniques adapted to

[8] If C is not the same in the two sectors, the condition (5) would include the cost difference. Equilibrium profits in the sector with the more expensive machines would have to exceed those in the sector with the less expensive machines by the cost difference. The general results would not change. I thank Prabal Roy Chowdhury for raising this issue.

intermediate-skills, and used by a larger customer base, would be expected to stimulate more of such adaptations.

Given endowments of H and O, relative price has to adjust to satisfy equation (5). From equation (4) relative price can change only if N_h/N_o changes. Therefore, the relative skill bias of technology has to adjust to clear the technology market. Equation (4) and (5) together give this equilibrium skill bias:

$$\frac{N_h}{N_o} = \frac{A_h}{A_o} = \left[\frac{H}{O}\right]^{\rho/(1-\rho)} \qquad (6)$$

Equation (6) implies that when $\rho > 0$, (or $\sigma > 1$) so the goods are gross substitutes, N_o rises with O. So the market size effect dominates the price effect. It follows a larger relative size of intermediate- skills, and markets for the products of such skills, will create more intermediate-skill biased technologies, as technology or organization of production responds to profit opportunities.

The size effect stimulates the creation of more intermediate technologies. But if the higher priced skilled factor is more productive, high-end innovation may still be more profitable. To see this, suppose there are diminishing returns to innovation in O but H has constant returns. For the market size effect to dominate, O must be sufficiently larger than H to compensate for the latter's greater productivity. If there are decreasing returns in the O sector, then Yo = No O^{α}, where $\alpha < 1$. The equilibrium condition (6) becomes $p_h H = p_o O^{\alpha}$. For more intermediate technologies to be created, O must exceed H by a multiple given by $1/\alpha$, that is $O > ((p_h / p_o) H)^{1/\alpha}$. Then there exists a threshold in the market size of B below which innovation will be high skill intensive and further the digital divide, and above which it will be inclusive[9].

A virtuous cycle[10] can occur if as the number of consumers of B and the revenues from selling B rise, more TP takes place in B. Since policies to increase use of B are a possible trigger for a virtuous cycle they must be emphasized. Large firms are normally capital and skill intensive and so develop A. But mobile technology is naturally more inclusive. The

[9] Acemoglu, Gancia, and Zilibotti (2012) derive a similar result more formally in an endogenous growth model of offshoring. TP increases inequality in the beginning but reduces it later.
[10] An example of tech driven virtuous cycles arises in a model of matching ICT to labour (Goyal, 2005) with endogenous choice of training and technology. Multiple equilibria are possible. Investment in training and technology can be at less than socially optimal levels, and policy intervention can lead to a shift towards better equilibria.

insights of this section help to assess how well Indian telecom (section 3) and mobile banking policy (section 4) have harnessed opportunities due to ICT.

3. Telecom policy

There was dynamism in a policy driven shift from fixed line to mobile telephony, with better incentives for private entry. This encouraged the development of intermediate technologies such as B. The National Telecom Policy was announced in 1994, followed by the New Telecom Policy of March 1999[11] and the recent National Telecom Policy (NTP) 2012 (GOI, 2012). The policies had similar themes, uniformly emphasizing the potential contribution of new technologies, inclusive innovation, competition, universal service, quality, India's security and its development as an export and manufacturing hub.

The 1994 policy focused on the funds required and saw privatization as a means of realizing these, but fell far short of its targets. In 1992 private operators were allowed in mobile telephony, with foreign partners to bring in the latest technology. Licenses were granted over 1994-95. Licenses were allotted to more than one provider in a circle to make sure there was competition.

The new policy of 1999 was a response to market players' concerns about poor revenue realization. The sector really took off after a move from a fixed fee to a revenue sharing model, since lower start-up costs enabled the development of and realization of profits from a large potential market. The Telecom Regulatory Authority of India, set up in 1997 and reconstituted in 2000, separated the regulatory function from policy-making, and aided the process. The non-Congress government then in power lowered license fees. Competitive entry led to many new businesses that did very well, even as one of the world's lowest tariffs ensured millions of poor could use the services.

The riches created, however, led to private corruption and public extortion that harmed the industry. In 2008 minister A. Raja, in the Congress coalition government allocated more 2G mobile licenses on a first come first served basis. The government auditor CAG alleged a large revenue loss to the government. The figure gained credibility from the INR 1062 billion

[11] See respectively: http://www.trai.gov.in/Content/telecom_policy_1994.aspx, http://www.trai.gov.in/Content/ntp_1999.aspx.

the government earned from 3 and 4G licenses allotted through auctions in 2010. So in 2012 the Supreme Court (SC) cancelled the old allocation and ordered new 2G auctions. But when they were held in November 2012 only 94 billion were raised against the 400 billion expected, casting doubt on the CAG figure that had triggered a series of corruption allegations. Subsequent auctions also failed.

The SC then clarified, in response to a Presidential query, resource allocation was a policy decision and therefore a prerogative of the executive. So the executive had flexibility in designing policy. An auction was not essential, but if the allocation was not in the 'common good', and did not satisfy the criteria of 'fairness and non-arbitrariness', as in the case of Raja's allocations, the SC could intervene.

Industry will always lobby to reduce taxes. But high imports are passed on to consumers, and reduce investment. Falling industry growth rates reduce future revenue to the government, and the welfare of the subscriber. Auctions have the desirable property of removing the government's discretion in allotting natural resources, which can be a major source of corruption. A single-step auction based allocation, with a low reserve price, and part of the payment to come from future royalties, could avoid both discretion in allocation and large upfront costs that reduce subsequent development. Apart from the contract, adequate competition can ensure prices remain low, and service quality improves, so the major gain from their natural resources, such as spectrum, goes to citizens.

NTP internalized these lessons by taking the position that the entry fee regime will be made flexible even as spectrum is made available at a price determined through market related processes. Pricing and competition are major factors affecting incentives. Affordable prices increase the customer base with reasonable returns for companies. Easier entry and revenue or profit sharing worked in the past.

Although easier private entry increased market size, policy failed to provide the requisite infrastructure. This meant intermediate technologies such as B remained out of reach of a large chunk of the population who remain stuck in technologies such as C, and the spillovers from ICT in compensating for failures in the spread of technologies Mark II, thus preventing the steepening of the budget line for the less well-off.

This is puzzling despite telecom receiving sustained policy attention, the contribution of ICT to the expansion of service exports and the export of virtual labour[12], and given its potential to contribute to inclusive growth which is a stated objective of the Indian government. Table 1, focusing on infrastructure relevant to telecom, shows that although a couple of States have done well, the average broadband coverage of village panchayats (VPs) and rural teledensity remains below 50 present. Unambitious short-term targets are set and even those are not achieved, let alone the universal access promised in every policy. Table 2 shows although rural penetration has increased in recent periods it remains below urban. Rural areas accounted for about 40 present of total connections in 2013.

Expansion of broadband is inadequate even in cities[13]. Only 10 present of the population has access to the Internet. In the financial capital, Mumbai, in 2013 the best available broadband was much below standards in an average US city and yet was six times more expensive. Table 3 shows continuing gaps in key parameters. This hinders the development of a supporting ecosystem and potential markets[14].

Place Tables 1, 2 and 3 about here

NTP recognized the potential of the mobile to be 'an instrument of empowerment' facilitating citizen-centric participative electronic service delivery in key neglected Mark II areas such as health, education, agriculture[15], skill development, employment, as well as in governance, and in secure financial transactions without constraints from the skill and literacy barrier. The recognition is not new, but technological developments in convergence, together with NTP's promise of a simpler and more enabling policy regime, better incentives and coordination, improve the chances of improving infrastructure.

[12] In 2011, at USD 84 billion, ICT exports exceeded any other Indian export item (World Bank database).

[13] It was only in 2004 that the Broadband Policy defined connectivity as 'An always-on data connection that is able to support interactive services including Internet access and has the capability of the minimum download speed of 256 kilobits per second (kbps) to an individual subscriber from the Point of Presence (POP) of the service provider', as compared to the 128 kbps that was earlier considered as broadband. India was far behind other Asian countries (see http://www.trai.gov.in/Content/broadband_policy.aspx).

[14] Broader yet relevant policy frameworks such as the Science, Technology and Innovation Policy (STIP) 2013, and its precursors also suffer from similar drawbacks in emphasizing R&D expenditure rather than factors that induce R&D. STIP aims to increase spending on R&D from the current 0.8 present in GDP to 2 present in the next five years. Mani (2013) writes this requires the share of private sector R&D to rise from the current 30% to almost 50%. The tax regime is already very generous—200 % super corporate income tax deduction for R&D. But private R&D investment tends to be concentrated in pharmaceuticals, chemicals and automotive industries, and is dominated by MNCs whose quick patenting reduces spillovers. More attention is required on increasing the demand-side of innovations using competition (Mani, 2013) and wider innovation in society (Abrol, 2013)--our market size effect.

[15] A specific example is the use of new service formats such as Machine-to-Machine communications for remote operation of irrigation pumps and smart grids, thus reducing current waste of water.

The evolution from analog to digital technology has facilitated the conversion of voice, data and video to the digital form. This implies future convergence in networks, services and devices, in turn requiring convergence of licensing, registration and regulatory mechanisms in these areas. Such regulatory convergence will enable flexible PPP participation to create the missing last mile connectivity. But good infrastructure is a pre-requisite. Broadband is the key driver for network connectivity of mobile technology and availability of spectrum. NTP aims to provide affordable and reliable broadband-on-demand by the year 2015 at minimum 2 Mbps download speed with higher speeds of at least 100 Mbps on demand; increase rural teledensity to 70 by the year 2017 and 100 by 2020; provide broadband coverage to all VPs by 2014 and all villages and habitations by 2020. It will also work towards a ‘Right to Broadband’.

Optical Fibre Network is planned to be laid to all villages and habitations using the Universal Service Obligation Fund (USOF), providing non-discriminatory and technology neutral access. The methodology for utilizing USOF is to be periodically reviewed and benchmarked against best practices in other countries. Even as rural expansion is incentivized, the aim is to optimally utilize existing infrastructure. To facilitate this, telecom is to be recognized as an infrastructure sector.

The licensing framework is to be simplified by creating one national license, full mobile number portability, and free nationwide roaming. Fixed-mobile convergence is expected to release spectrum for other wireless services. Delinking of the licensing of networks from service delivery to end users is expected to enable optimal and efficient utilization of networks and spectrum as operators share active and passive infrastructure even as adequate competition is ensured through resale at the service level. Content neutral carriage charges, based on bandwidth utilization, are expected to also encourage non value added services, such as provision of data and information, on mobiles, even as competitive provision of value added services grows. These changes will themselves enhance infrastructure and allow it to be used more flexibly. Enforcing the VOIP facility will enhance affordability.

Infrastructure is used and created if there is a demand for the services it can provide. NTP aims to coordinate closely with all stakeholders, including other government entities to ensure last mile access, local content creation in regional languages, thus developing an ecosystem for broadband. Absence of coordination, even within the government, is a major reason for past failures.

The themes echo past policies but NTP adds value in emphasizing better governance and incentive structures. In addition to using price and competition based incentives, NTP also aims to improve regulation. Institutional, legal, and regulatory frameworks are to be strengthened, processes re-engineered, there is to be regular audit of spectrum usage, and better grievance redressal mechanisms for consumers.

NTP seeks to facilitate the active role of both private sector and different tiers of Government in expanding telecom infrastructure by smoothing coordination, for example, by establishing an appropriate institutional framework and by simplifying the right of way policy for tower installation and laying of cable network. It also aims to promote synergies between broadband roll-out and other related Government programs. Taxes, duties and levies on the sector are to be rationalized even as a stable fiscal regime stimulates investments and lowers costs.

All telecom policies have sought, unsuccessfully, to boost domestic production and exports of telecommunication equipment and products. But NTP breaks new ground by creating better incentives. It promotes an ecosystem to meet Indian telecom sector demand and provides fiscal and financial incentives and specific guidelines for giving preference to domestic manufactures. Telecom service providers are to be asked to commit to purchase indigenous products that are comparable in price and performance to imported products, participate in trials of new indigenous products, and place pilot orders for them. Indian IPRs are to be incorporated in global standards; and open platform standards mobile phones encouraged to make India a global hub for value added services.

Better incentives will help but appropriate and timely decisions have also to be made. NTP lays down underlying principles to balance the interests of consumers, service providers and government revenue. But although competition is a stated principle, a duopoly in undersea cables raises costs of Internet connectivity. Although consumer interest is a stated principle, the Government has not acted on the leeway given by the Supreme Court to reduce the fixed charge in auctions, thus ignoring lessons from past policy successes in expanding markets. Although convergence and flexibility is a stated principle, Bharati has not been allowed to share 3G spectrum. Reliance has brought a case against Bharati to prevent them from such sharing. Inaction is harming a major potential for inclusive innovation.

The analytical framework developed in the section above suggests improved implementation has the potential to change the slopes of LL, as better infrastructure substitutes for scarce private capital. This, together with the emphasis on the local ecosystem, can increase market size. Then technique B can develop in a virtuous cycle of induced improvement. This section shows despite some success in developing B, failures in developing supporting infrastructure limited market size. The section below shows how, despite the growth in mobile use, absence of a focus on market size in banking policy limited growth of mobile banking, thus limiting spillovers from mobile telephony.

4.1 Harnessing mobile telecom in payment systems

A major potential inclusive application of mobile technology is in mobile banking. About 60 present of the Indian population remains unbanked. Although new technologies offer many opportunities, banks seem to be slow in making use of these. But rapid growth in mobile usage, their wide penetration, competition and dynamism in designing new products, suggests mobile financial services could enable rapid strides in financial inclusion. Delays and transaction costs could fall for users.

But the RBI’s preference is that banks use the services of business correspondents (BCs), with the definition expanded to include large corporates and small shops as BCs, to further inclusion. In mobile banking remittances have to be from bank account to bank account. It wanted to give banks the opportunity to leverage new technology and extended agent network. Although payment gateways for e-commerce are also regulated by the RBI, and electronic payments are regarded as very secure with modern payment legislation, it was reluctant to allow person-to-person transactions, and deposit holding by non-banks, because of potential risks to deposit holders. Concerns also remain on sources of funds since it is difficult to implement know your customer (KYC) with mobile service providers (MSPs). Their prepaid customer identification processes are lax as such customers pose a low financial risk for them. Given the large potential numbers of such cards, it is difficult to contain risks of anonymity, elusiveness and poor oversight.

Moreover, the belief was pure MSP transfers may not be so useful, since the use of electronic money was not yet widespread. RBI mandated charges, and subsidy for banks issue cost of biometric access/smart cards, make account-to-account fund transfers the cheapest mode of remittance. A bank-to-bank fund transfer of INR 1 lakh using NEFT would cost only INR 5/- for the customers. In contrast a fund transfer of 1,000 Ksh (Kenyan Shilling) in M-PESA, the Kenyan MSP, costs the remitter 30 Ksh and the recipient between 25 Ksh to 75Ksh. Failure of bank transactions are expected to be lower compared to SMS based transactions. Failure to process transactions, or confirmation not received due to peak congestion, are major sources of M-PESA customer dissatisfaction. Resolution of complaints takes a long time because of the high volume of such calls.

In a smart card based technology, an agent is required for initiation of all transactions. Account details and the transaction data are stored on the smart card. The RBI is open, however, to mobile banking which links payment gateways and MSPs to banks. BCs are then required for enrolment, cash deposit and cash withdrawal, since all transaction data are held on the mobile phone. Mobile-based products could make customers independent of agents. Because the overarching goal is to expand financial services to unbanked population, permitted points of service for small value transactions are being expanded, for example, by allowing MSPs to function as BCs.

The provision of additional banking services, increasing access to credit, and raising the level of savings, for those currently excluded from the formal financial sector is the additional advantage of bank involvement. India has about 100 million migrant workers from central India who need to send remittances home. In Africa remittances sent across borders are known as “taxi money”, because of the taxis that routinely carry it (Maimbo et. al., 2010). A cost of transfer much below informal transfer methods encouraged entry into the formal financial sector. M-PESA provides a virtual prepaid payment product, used widely for remittances. The MSP is allowed to retain the pre-paid amount and make person-to-person payments. M-PESA model also uses a National-ID scheme, yet to come up in India.

Wizzit Bank in South Africa and G-Cash in Philippines are successful models of partnership between banks and MSPs. The Central bank in the Philippines worked with mobile operators to provide branchless banking; Brazil also has 10 years of experience. Wizzit provides bank accounts on mobile phones with MSPs support. Services like person-to-person payments, transfers and pre-paid purchases, and use of a Maestro card for cash withdrawal are provided.

ICT and telecom developed similarly in India and Pakistan (Table 2) with India ahead on most parameters by 2011. The regulatory structure for mobile banking was set out in 2008 in both countries. But even four years after the approval for mobile banking transaction, Indian volumes remained low, although there is some growth. Mobile banking transactions doubled to 5.6 million in January 2013 compared to 2.8 million in the previous year[16]. But this was tiny given the large mobile subscriber base. Pakistan, with a much smaller population, already had double this number at 10.4 million transactions in September 2012 (SBP, 2012). So it is helpful to compare the regulations in India with those Pakistan, and to see if our analytical framework helps to identify crucial differences.

4.2 Regulatory requirements for Internet and mobile banking

The regulatory perspective in this rapidly changing area follows concerns first enunciated in the RBI guidelines for Internet banking. Mobile banking transactions were defined as undertaking banking transactions using mobile phones by bank customers that involve credit/debit to their account. The guidelines for Mobile Banking Transactions initially set out in October 2008 mandated that all transactions have to originate from one bank account and terminate in another bank account.

Initial regulatory clarifications related especially to:

1. Technology and Security Issues

Logical access control techniques and technological up gradation ensure secure Internet banking. Sensitive data like passwords are encrypted in transition. Periodic checks, tests and back-ups are prescribed, and every breach or failure of security systems is to be reported to RBI. Banks have to put in place appropriate risk mitigation measures like transaction limit (per transaction, daily, weekly, and monthly), transaction velocity limit, fraud checks etc. Validation through a two-factor authentication, one of which is mPIN or any higher standard, with end-to-end encryption, was initially required at all stages of transaction processing irrespective of value limit. The mPIN was not to be in clear text anywhere in the network.

[16] See news report at http://www.business-standard.com/article/finance/mobile-banking-transactions-double-payments-rise-threefold-113041100353_1.html

Standardized message formats like ISO 8583 are to be adopted for inter-operability between banks, and between their mobile banking service providers. Until the creation of a 24x7 robust national clearing and settlement infrastructure, banks are allowed to enter into bilateral or multilateral arrangement for inter-bank settlements, ensuring inter-operability.

2. Legal

Bilateral contracts are to be drawn up between the payee and the payee's bank, the participating banks and service provider that clearly define the rights and obligations of each party. Banks must make mandatory disclosures of risks, responsibilities and liabilities of the customers. They must be aware of customer rights, the extent to which they can be satisfied in the new environment, and how to protect themselves from new threats such as hacking. Customer complaints and grievance mechanism were laid down.

3. Sources of Funds

Absence of full capital account convertibility implies restrictions for Internet banking also. Only banks licensed and supervised in India and with a physical presence in India are permitted to offer Internet banking products to residents of India. The products are restricted only to account holders and to local currency products. Existing exceptions for limited purposes, under the Foreign Exchange Management Act, such as where resident Indians maintain accounts with overseas banks, are permitted. Overseas branches of Indian banks can offer Internet banking services to overseas customers, but must satisfy both the host and the home supervisor. Guidelines on KYC, Anti Money Laundering, Combating the Financing of Terrorism and filing Suspicious Transaction Report to Financial Intelligence Unit–India are applicable to mobile based banking services also. These necessitate mandatory physical presence for registration of customers. Document-based registration is also required before starting the mobile banking service.

Banks were to seek one-time prior approval of the Reserve Bank of India for starting mobile services after obtaining their respective Board's approval. Such services could also be offered through the BCs.

An initial daily transaction limit prescribed was INR 5000/- per customer for funds transfer and INR10,000/- per customer for transactions involving purchase of goods or services. But these were successively relaxed. On December 24, 2009, the daily cap transaction limits for funds transfer and for purchase of goods and services was raised to INR 50,000. Transactions upto INR 1,000 were allowed without end to end encryption of messages. Cash-outs to the recipients were permitted through ATMs or BCs subject to a cap of INR 5,000 per transaction and a maximum of INR 25,000 per month per customer. On May 4, 2011 the transaction limit without end to end encryption was raised to INR 5,000. On December 22, 2011 the transaction cap of INR 50,000 per customer per day was removed. Banks were allowed to place their own limits based on their risk perception with the approval of their Board. The ceiling on cash-outs to the recipients through ATMs or BCs was raised to INR 10,000 per transaction subject to the existing cap of INR 25,000 per month (Khan, 2012). The RBI lowered reporting requirements on the reasoning that small amounts cannot be used for terrorist financing. It also permitted non-bank entities to issue mobile-based prepaid payment instruments, based on representation from MSPs. But the response was poor.

These changes responded to demands. Banks' found end-to-end encryption costly, and wanted to avoid it for low value transactions. They wanted limits to be revised upwards to permit transactions like air-ticket purchases. They found entering into partnerships with MSPs difficult, with conflicts over each party's value creation. For example, MSP's think banking is only a value addition since they provide their mobile customer base. But banks think mobiles provide only an additional access channel, similar to the Internet, for their customer base. MSPs may be interested in the financial float. But RBI regards this as equivalent to deposit taking, which it is not willing to allow non-banks, since of problems in extending deposit insurance to non-banks.

Pakistan also started in 2008 with a bank led model which was expected to continue until the players and stakeholders gained some maturity. It was also not restricted to MSPs but could be offered through fuel distribution companies, Pakistan post and chain stores. Like India, customer account relationship had to reside with some financial institution (FI) and each transaction had to be through the customer account with no actual monetary value stored on the mobile-phone or server.

Permissible activities included opening and maintaining a branchless bank (BB) account, account-to-account fund transfer, person-to-person fund transfers, cash-in and cash-out, bill payments, merchant payments, loan disbursement or repayment, and remittances.

BB accounts were categorized in three levels. Level 1 BB accounts are for individuals only, level 2 accounts can be opened by individuals as well as by firms, entities, trusts, not-for-profit organizations, legal persons etc., and level 3 BB accounts are for businesses only. Different KYC norms for these levels were laid down by SPB, subject also to the FIs policies.

The maximum balance for Level 1 was 60000, for level 2 and 3 it was set by the FI. The limit on debit/credit for Level 1 was 10000 per day, 20000 per month and 1,20,000 per year, for level 2 and 3 it was set by the FI. FIs had to make sure that customers did not breach their limits, sending them alerts when they were close to their limit, and they had to identify suspicious transactions.

Amendments in 2011 included introducing a level '0' to encourage involvement and learning by low income segments. The transaction and maximum balance limits on Level "0" accounts were Rs. 15,000 daily limit, Rs. 25,000 monthly limit, Rs. 120,000 annual limit and Rs. 100,000 maximum balance limit. The biometric fingerprint scans requirement for account opening, that had discouraged participation, was removed. Accounts could now be opened electronically with a digital image. Physical presence was no longer essential. The transaction and maximum balance limits applicable to Level "1" Accounts were increased as follows: Daily Limit Rs. 25,000 (previous limit was Rs 10,000), Monthly Limit Rs. 60,000 (previous limit was Rs 20,000) and Annual Limit Rs.500,000 (previous limit was Rs. 120,000). The Maximum Balance Limit was removed. Account-to-person and person-to-person fund transfers facilities were introduced and payment of utility bills was excluded from normal transaction limits (SBP 2008, 2011 and 2012).

Comparison: So Pakistan also insisted on a key role for FIs and data records to ensure security and stability. But the differences were higher initial levels and limits, more income categories, a wider universe of BCs, more flexibilities and functions for FIs, and reduction of transaction costs. These features brought in both the more and the less well off, increased creativity in use, linking it more closely to customer needs. Thus it increased market size and sustained cumulative use. Bill payments and P2P transaction accounted for more than 80 present of Pakistani mobile transactions (SBP, 2012).

Mobile payment systems and wireless broadband are preconditions for mobile banking to succeed. They are in place in both countries, although improvements are possible and are on-going. For example, Bhandari and Kale (2010) argue that after the Payment Act India has the most advanced regulation in the world in this area. They argue MSPs' provision of value added services has been inadequate. Transaction costs are probably higher because of security concerns. As UID is implemented KYC will become easier. Together with the UID Authority of India, the National Payments Council of India is working on a National Automated Clearing House or switch for mobile to mobile payments, called India Pay Mobile Switch, which will enable UID to UID micropayments. A UID would be linked to a mobile number and a bank account in a central database. Any bank or mobile phone enabled BC can then initiate a payment, which will be credited to the beneficiary's bank account linked to her UID.

The cost of smart phones is also expected to fall from INR 25000 to INR 5000, and together with cheaper cloud computing, enable a jump in Internet usage. Business opportunities for service providers will also expand with rapid growth planned in electronic government transfer payments. Thus the market size of intermediate technologies is reaching the critical threshold. In responding to the opportunity, policy must identify measures that raise market size. Careful system design to keep transaction costs at a minimum and improve flexibility is critical.

5. Conclusion

The analysis shows that in order to shift the excluded to higher productivity intermediate techniques, policy can either lower the cost of the technique through innovation or make more capital available to the less well off, thus improving the rate at which they can substitute low for high skills. This could be done through credit subsidies, income transfers, reducing technology and transaction costs, or through better public provision of the relevant infrastructure since it more difficult for the less well-off to compensate privately for poor public infrastructure.

If goods of different quality are gross substitutes, innovation rises with the market size effect. The latter overcomes the price effect, which favours high skills, after the market size for intermediate technology crosses a threshold determined by relative prices, productivity and quantity. Therefore the second policy set is to be preferred since it can achieve the first in a decentralized manner, with less scope for policy errors. A virtuous cycle can occur if, as the number of consumers of and the revenues from selling intermediate technologies rise more innovation takes place in such technologies. Of the second policy set, infrastructure is to be preferred to income transfers since it directly increases productivity harnessing the fruits of the Mark II technological revolution, even as the Mark III, ICT, improves inclusion as well as spreads Mark II. Better infrastructure also suits the needs of India's demography as large numbers of young enter the workplace. Transfers suit the shrinking set of the persistent poor. Although inclusive growth is the Indian policy objective, the potential of ICT for inclusion is not well understood.

Although mobiles, which met a real need, spread rapidly in India as freer private entry reduced costs, there were failures in the provision of complementary infrastructure such as broadband. Clarity regarding the importance of easier entry was lost. This reduced technology spillovers and the markets size for applications. Comparison of India's mobile banking policy with that of Pakistan illustrates measures limiting market size were partly responsible for India's comparative failure.

The 2012 telecom policy internalizes some of these lessons and promises change on multiple fronts. More flexibilities, coordination, better incentives and governance may address weaknesses in implementation, last mile connectivity and the required ecosystem. But policy action is still lacking. It has not seized the opportunities to establish new innovation friendly principles created by the failures of recent auctions, the Supreme Court's revision of its stand on auctions, and private cases against spectrum sharing. A clear policy focus on market size would generate more innovations that sustain inclusive growth.

The analysis can be extended in a number of different directions. The analytical results can be derived in a more fully specified non-linear model. The effect of market size on inclusive innovation can be tested rigorously with a cross-country panel data, and further case studies of specific EDEs undertaken.

References

Abrol, D. 2013. 'New science, technology and innovation: A critical assessment'. *Economic and Political Weekly*. 48(9), pp.: 10-12. March 2.

Acemoglu, D., G. Gancia, and F. Zilibotti. 2012. 'Offshoring and directed technical change'. *NBER working paper no. 18595*. Available at http://www.nber.org/papers/w18595.

Acemoglu, D. 2002. 'Technical change, inequality, and the labour market'. *Journal of Economic Literature* 40, pp.: 7-72.

Avgerou, C. 1998. 'How can IT enable economic growth in developing countries?'[online] *London: LSE Research Online*. Available at http://eprints.lse.ac.uk/2581/

------ 1998. 'Why do new technologies complement skills? Directed technical change and wage inequality'. *The Quarterly Journal of Economics* 113 (4), pp.: 1055-1089.

Bhandari, L. and S. Kale. 2010. 'Financial inclusion via universal access to electronic payments, in India on the growth turnpike'. *Essays in Honour of Vijay L. Kelkar*. Sameer Kochhar (ed.). Academic Foundation: New Delhi.

Chakrabarty, K. C. 2010. *Mobile commerce, mobile banking: the emerging paradigm* http://www.rbi.org.in/Scripts/BS_ViewBulletin.aspx?Id=10854

Cecchini, S. and C. Scott. 2003. 'Can information and communications technology applications contribute to poverty reduction? Lessons from rural India'. *Information Technology for Development*. Vol. 10, pp.: 73-84

Diamond, J. 1997. *Guns, germs, and steel: The fates of human societies*. W.W. Norton and Co., New York.

Freeman, R. 1986. 'Demand for education'. In O. Ashenfelter and R. Layard. (Eds.), *Handbook of Labour Economics*, Vol. I. Elsevier, North Holland.

GOI (Government of India). 2012. *National Telecom Policy-2012*, Department of Telecommunications, June 2012, accessed from http://www.dot.gov.in/ in January 2013.

Goyal, A. 2005. 'New technology and labour markets: Entrants, outsourcing, and matching'. *The Indian Journal of Labour Economics*, 48(4), pp. 853-868. October-December.

----- 2007. 'Distant labour supply, skills and induced technical change'. *Information Analysis and Policy*, 19(2), pp. 133-150. June.

----- 2011. 'Developing women: Why technology can help'. *Journal of Information Technology for Development*, 17(2), pp. 112-132, April.

----- 2012. 'An appraisal of five year plans and the future'. *Yojana*, special issue on 'An Approach to 12th Five Year Plan– Issues and Challenges'. January.

Hasan, R., D. Mitra, and A. Sundaram. 2012. 'What explains the high capital intensity of Indian manufacturing?' *Indian Growth and Development Review*.

Hayami, Y. 1998. ‘Toward an East Asian model of economic development’. In: Y. Hayami and M. Aoki. (Eds.), *The Institutional Foundation of East Asian Economic Development*. IEA Conference volume No. 127. 3-35. Macmillan, New York.

Jones, R. W. and H. Kierzkowski. 2005. ‘International trade and agglomeration: An alternative framework’. *Journal of Economics*, Supplement 10, pp.: 1-16.

Jorgenson, D. 2001. ‘Information Technology and the US Economy’, *American Economic Review*, vol. 91, no. 1, pp. 1-32.

OECD. 2002. Measuring the Information Economy, *OECD*, Paris.

Khan, H. 2012. ‘Customizing mobile banking in India: issues and challenges’. *Address delivered by Deputy Governor, Reserve Bank of India*, at the FICCI-IBA (FIBAC) Conference, September 5 Mumbai, accessed from http://rbidocs.rbi.org.in/rdocs/Speeches/PDFs/CMBI060912SC.pdf on January, 2012.

Kapoor, R., 2010. ‘Financial inclusion: Game changer for urban renewal’. *The Economic Times* Mumbai, 20 September.

Maimbo, S., T. Saranga, and N. Strychacz. 2010. ‘Facilitating cross-border mobile banking in Southern Africa’. *The WB Economic Premise*, No. 26. August.

Mani, S. 2013. ‘The science, technology and innovation policy 2013: An evaluation’. *Economic and Political Weekly*. 48(10), pp.: 16-18. March 9.

Mani, S. 2007. ‘Revolution in India’s telecommunications industry’, *Economic and Political Weekly*, 42 (7), pp. 578-580. February 17.

Schmookler. J., 1966. *Invention and Economic Growth*. Harvard University Press: MA.

SBP (State Bank of Pakistan). 2008. ‘Branchless banking regulations for financial institutions desirous to undertake branchless banking’. *Banking Policy & Regulations Department*, March 31, http://www.sbp.org.pk/bprd/2008/Annex_C2.pdf

----- 2011. ‘State Bank revises branchless banking regulations to bring low income segment of society into financial loop’. June 20, http://www.sbp.org.pk/press/2011/Regulations-20-Jun-11.pdf

---- 2012. 'Branchless Banking Newsletter: Leveraging Technologies and Partnerships to Promote Financial Inclusion'. Issue 5, July- September. Available at http://www.sbp.org.pk/publications/acd/BranchlessBanking-Jul-Sep-2012.pdf

Subramanian, A. 2013. ‘This is a golden age of global growth (yes, you read that right)’. *Financial Times*, April 7. Available at http://www.ft.com/intl/cms/s/0/d69ec792-9e08-11e2-9ccc-00144feabdc0.html#axzz2Pw8fxvmR

Table 1: Per cent broadband coverage of Village Panchayats under Bharat Nirman-II and rural teledensity				
State /UTs	**Broad-band covered (March 2011)**	**Per cent of 2010-11 target achieved**	**2010-11 target as a per cent of uncovered panchayats**	**Per cent rural teledensity (end Feb 2011)**
Andhra Pradesh	58	70	26	35.1
Assam	25	50	21	25.4
Bihar	50	105	55	29.0
Chhattisgarh	22	0	19	2.8
Gujarat	53	39	22	48.2
Haryana	84	74	202	53.0
Himachal Pradesh	51	47	41	71.8
Jammu & Kashmir	21	0	36	29.6
Jharkhand	56	158	78	2.3
Karnataka	61	65	67	36.7
Kerala	100	80	500	54.5
Madhya Pradesh	18	20	38	31.8
Maharashtra	37	15	35	47.5
Nagaland	88	0	100	8.2*
Orissa	34	51	34	29.9
Punjab	81	50	62	58.8
Rajasthan	32	25	33	39.3
Tamil Nadu	62	21	31	50.2
Uttar Pradesh	47	102	51	29.0
West Bengal	47	38	44	38.1**
Total	**45**	**59**	**39**	**35.2**
Average	**50**	**44**	**51**	**34.8**

Notes: * Arunachal Pradesh, Manipur and Nagaland ; ** West Bengal including Sikkim

Source: Calculated from March 2011 report to DU PMO available at http://www.dot.gov.in/

Table 2: Rural urban differences in teledensity					
	Total wireless subscribers (in million)	**Rural share (%)**	**Teledensity**	**Urban teledensity**	**Rural teledensity**
March 2013	867.8	39.5	70.9	140.7	40.2
June 2012	934.1	36.0	77.0	162.5	39.8
June 2009	427.3	29.5	36.6	87.2	15.4

Source: http://www.trai.gov.in/Content/PerformanceIndicatorsReports.aspx?ID=1&qid=1

	Table 3: Comparing ICT and mobile use in India and Pakistan					
	Fixed broadband Internet subscribers (per 100 people)		**Internet users (per 100 people)**		**Mobile cellular subscriptions (per 100 people)**	
	India	**Pakistan**	**India**	**Pakistan**	**India**	**Pakistan**
1991						0.007
1992						0.011
1993						0.013
1994			0.001			0.020
1995			0.026		0.008	0.032
1996			0.046	0.003	0.033	0.052
1997			0.071	0.028	0.088	0.101
1998			0.139	0.044	0.117	0.142
1999			0.273	0.055	0.182	0.188
2000			0.528		0.339	0.212
2001	0.005		0.660	1.319	0.610	0.503
2002	0.008		1.538	2.577	1.194	1.129
2003	0.013		1.686	5.041	3.046	1.570
2004	0.021		1.976	6.164	4.650	3.223
2005	0.118	0.009	2.388	6.332	7.907	8.050
2006	0.199	0.016	2.805	6.500	14.35	21.37
2007	0.267	0.027	3.950	6.800	19.90	38.22
2008	0.443	0.089	4.380	7.000	29.13	52.57
2009	0.641	0.178	5.120	7.500	43.48	55.33
2010	0.897	0.306	7.500	8.000	61.42	57.14
2011	1.075 (27)	0.417	10.07 (78)	9.000	71.99 (95)	61.61
2012	1.137 (28)	0.515	12.58 (81)	9.964	68.72 (98)	66.77

Note: Figures in brackets are for the US
Source: International Telecommunication Union, World Telecommunication/ICT Development Report and Database, and World Bank estimates.

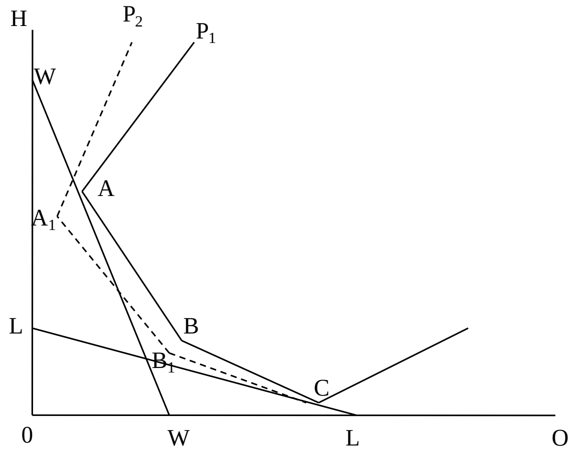

Figure 1: Capital biased technical change

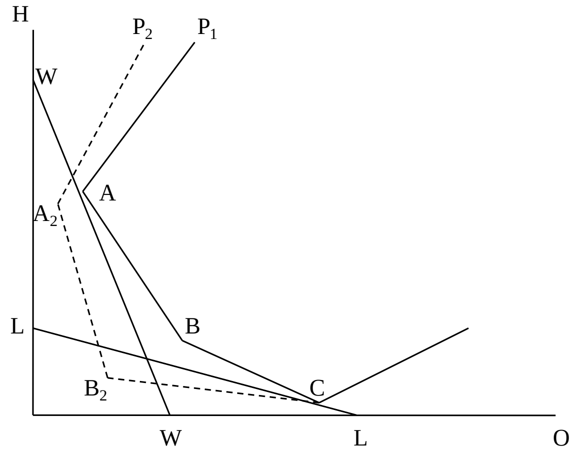

Figure 2: Intermediate technology biased technical change