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Emerging Markets and the IoT

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Abstract—Emerging market economies rarely lead the commercialization of emerging technologies. This was understandable when emerging technologies were based on costly physical product technologies that produced products like airplanes, automobiles and more recently semiconductors and MEMS devices. Yet we are now in the information- or knowledge economy-based Schumpeterian cycle where exceptional infrastructure cost no longer apply. Emerging markets today have in many cases both the technological expertise and the infrastructure capital to embrace at least the IoT emerging service product technology base. If this is so, then what are the business models that are appropriate for emerging markets? Our research focuses on adding to the literature by investigating the differences between physical product-based and service product-based emerging technology adoption in emerging markets. We construct and demonstrate a comprehensive policy-based tool for the review of IoT-based (i.e., Software as a Service-based) opportunities.

I. Introduction

Emerging market economies rarely lead the commercialization of emerging technologies [1], [2]. Some think this is due to the nature of the technologies that underpin Schumpeterian cycles [3]: earlier Schumpeterian waves in particular were derived from technologies whose production infrastructure was simply to expensive for emerging market economies [4]. If this is the case, then what is a viable development pathway for an emerging market economy? Some see emerging market economies as potential low-cost producers of established technologies. In this role, these economies might eventually develop to begin manufacturing physical products based on emerging technologies such as nanotechnologies and MEMS [5], [6], [7]. Others see opportunity in service products, where emerging technology-based infrastructure requirements are often much lower than those employed by traditional products [8]: lower emerging service technology infrastructure costs may enable emerging market economies "leapfrog" and skip to a new learning curve [9]. Some focus on the role of the entrepreneurs [10], [11]. Some look to large firms and regions utilizing portfolio techniques [12], [13]. Still others look at triple and Quadruple helix economic cluster theory techniques for emerging markets [8], coupled perhaps with new emerging market policy [14].

Today we have seen a change in thought on the prospects of commercializing potentially disruptive technologies [15] in emerging market economies and even in the "Bottom Billion" economies [16]. This change is likely due to the more limited cost of service-based disruptive technology infrastructure. This less expensive infrastructure is resulting in part in developments in the Internet of Things (IoT) space, as in the Internet of Things (IoT) service product of mobile payment [17], in new business models based on disruptive technologies [18], and even in potential IoT growth at the Base of the Pyramid [19], [20]. Yet the full application of IoT in emerging markets faces many hurdles.

Here we add to the literature by investigating first the difference between disruptive emerging technology-based physical products [21] and emerging technology-based service product adoption in emerging markets [22]. We utilize case study research techniques that emphasize secondary data sources of firms in the emerging Indian marketplace. We emphasize a policy-business nexus for emerging market due in part to its ability to address some of the large 21st century world societal challenges. We focus on the IoT emerging technology-based product applications that are most likely to be utilized by emerging Markets.

II. Literature Review

A. Research Plan

We first review the business cycle literature on disruptive technologies and Schumpeterian waves. We next review the historical use of disruptive technologies by emerging markets. We then more closely examine the basis of the current information-based Schumpeterian cycle to better understand if conditions had changed that enhance the ability of emerging market to embrace the emergent Schumpeterian wave disruptive technology base. We show that the conditions in terms of technology [23], infrastructure cost, and knowledge

have changed to allow emerging market-based firms to be based on disruptive technologies.

B. Disruptive Technology-Based Business Cycles

Schumpeterian Waves [24] define how emerging technologies create new economic opportunity, how and where they are adopted by the public [25], [26], and the how corresponding innovation spawns around the core disruptive technologies [27]. The water wheel, commercial textiles and ironwork industry came to the forefront in 1785 where Europe and especially the UK led the way. This industry was subsequently replaced in 1845 by the steam, rail and steel industry. This new industry was the first Schumpeterian cycle dominated by the United States and the United Kingdom (both developed economies). Schumpeterian waves underpinned by emerging technologies fueled and refreshed the Industrial Revolution. The next cycle was fueled by electricity, chemicals and the gasoline engine developed around the turn of the 20th century [28]. The producers and users of these were again the developed markets. Further cycles were enabled by technologies that gave us the automobile, electric light bulb, and blasting-based mining practices. Aviation technologies came to the forefront in 1950s, post-world war II. The 1980s, provided the beginning of the next cycle with the mass market semiconductor technologies spawned the global Information Technology (IT) age. These cycles are increasingly formed with the aid of the government policy, often through cluster theory [29] (Haak et al 2014) and advanced roadmapping [30].

Schumpeterian cycles have shown a decrease in time that the average business cycle enjoys [31]. The water wheel, textile and ironwork age were replaced by the steam engine, rail and steel age in about 60 years. However, commoditization of petrochemical products dominated economies for only 40 years. The current cycle initialized by IT technologies is projected to last for only 30 years. The rate of emerging technology dispersion, and commoditization for economic rent, is accelerating.

C. Business cycles and emerging markets

These Schumpeterian cycles have historically been initiated in developed economies and particularly those that embraced the creative destruction that comes with emerging disruptive technologies [32], [33], [34] often through entrepreneurial firms [10]. In turn these regions have benefited the most from them. Historically, emerging market economies have not been involved in, nor have they benefited from, emerging technologies in the early part of the cycle development. The majority of economic gain that was derived by emerging markets were gained as developed economies sought lower cost regions to produce industry accepted products as the business cycle progressed [35], [14], [36].

It is only in recent times that emerging markets have started developing "leapfrog" solutions that leverage a combination of government policy, low cost technology enablers, and the biggest ingredient, a billion plus potential customers [17]. According to our analysis, emerging markets are typically ill-suited to absorb the excessive costs of a physical product-based industry where development costs are relatively high. Further, business practices have been a deterrent to emerging market based disruptive technology commercialization [37]. However, service product-based industries like wireless connectivity, IT, medical services [38] and smartphone-based services [39], [40] have relatively low initial capital costs and can benefit from the inherent scaling benefits.

D. Disruptive service-based technology and Business cycles

Service markets, and innovation in the sector, have increasingly become important [41]. Barras [42] initiated innovation research specific to the service sector when he demonstrated that, in the services product sector, process or infrastructure innovation preceded product innovation--completely out of phase with innovation in fabrication and assembly physical products [43] and materials-based products [44]). The importance of services especially to the knowledge and information economy created new initiatives [45] and efforts to categorize them [46] for better understanding.

Innovation in the service sector is important and different. Service-based technologies are part of the foundation of a Schumpeterian business cycle. The IoT infrastructure, a service-based technology infrastructure [47], [48], is central to the emerging Schumpeterian business cycle.

Service infrastructure technology is the key to service product success [49] (Berg and Einspruch 2009). The IoT ecosystem in emerging markets is serviced by a larger and increasing number of system integrators than actual physical products (see Figure 3). Components of the physical infrastructure [50] underlying the IoT solutions are usually imported or sourced through international vendors and application, analytics and outcome-based services built on top of them by the systems integrators [51].

The IoT emerging technology base provides the scale and cost of market entry that can be afforded by many if not all emerging market economies. Many seek private public partnerships to fund, and accelerate at all costs, what many consider to be the harbinger of the next Schumpeterian cycle. According to a recent report [52], the global service product opportunity that arises from servicing the IoT use cases is more than two times than the potential product, goods or infrastructure revenue.

E. Disruptive Service-Based Technologies, Business Cycles, and Policy

Schumpeterian Waves form the basis for comparative regional economic prosperity through technology innovation. Government Policy plays an important role in technology development [53], [54] and often is the foundation for National Innovation Systems [55]). Yet the history of nations and regions in formalizing National Innovation Systems policy is relatively short. National Innovation Systems policy gained importance during post-WWII Cold War activities [56]. But it has been focused on physical product technology development rather than service product technology development, and that focus has had consequences.

Most national technology policies come from developed economies, but developing economies are now embracing them as well [55]. This coincides with the similarly recent trend of

National Innovation Systems policy being increasingly influenced by cluster theory [57], [58], [59]. Still much of the emphasis is on physical product-based emerging and disruptive technologies such as nanotechnology [8], and it is at the moment unclear what emerging market economies could learn from these initiatives.

The nature of innovation in service sector-based technology is different, and the nature of IoT as a potential disruptive emerging service product technology enabler intensifies this difference. The traditional product-process innovation dichotomy may not be relevant: the real value in the IoT lies in neither. It inheres in the system and the data generated by all the devices [60]. The services revenue, through a combination of intelligent applications, analytics, and system integration services, presents a far larger revenue opportunity for both developers and users of IoT enabled use cases. How governmental policy can best assist this process is not yet fully understood, and is a subject of the present study.

F. Tool Generation

Our disruptive service technology-based innovation tool for firms in emerging markets is based on secondary rather than primary data. This insures that objective quantitative data is employed, rather than personal perception. Its design intent is for use with open innovation scenarios, entrepreneurial firms and established enterprises. The basis of this tool rests on manifold assumptions, as discussed above. The nature of services is different than that of physical products. The current state of emerging market economies differs greatly from developed markets. The emerging Schumpeterian cycle, based on technologies like the IoT, is leveling the playing field in terms of cost and through its use creating opportunity to generate the knowledge to use it across the world. Post-WWII national technology policy has focused on physical product technologies.

We respond to these assumptions by constructing a comprehensive policy-based tool for the review of IoT based opportunities (Figure 1). We operationalize our concepts by depicting the nature of government policy (Government Policy), the nature of the private sector enablement (Private Sector Enablement), the cost and availability of technology (Technology Enablement), size of opportunity (Revenue Opportunity) and the amount of customer education required to use the product (Customer Education).

	Government Policy	**Private Sector Enablement**	**Technology Availability**	**Revenue Opportunity**	**Customer Education**	**Outcome**
Company 1						
Company 2						
Company 3						

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Fig. 1. Disruptive service technology-based innovation tool for firms in emerging market economies.

III. METHODS

We demonstrate the use of the tool (Figure 1) through a modified case study approach [61], [62], [63]. We focus on firms providing IoT-based services in an emerging market economy – India. Six case studies are considered through the use of secondary data. This does not preclude the use of other parties with proprietary data to populate the model with that data. We have three success cases and three failure cases. In the three success stories we followed up after our analysis was complete to verify the accuracy of our information. For the purpose of the six exemplar cases, we have cited websites, books and articles as they are easily accessible and as such meet the expectations of references for a publication in an academic journal practitioner may wish to use other sources (Appendix 1). . The six cases involve large firms and IoT-based startups operating in either the industrial or the governmental service market sector. We begin with the three success stories.

A. Success Cases

India has an exemplary record of how innovative technologies and enabled services and use cases can be hyper-scaled and leapfrog more mature markets. Yet a systematic look at the factors such as government policy and technology enablement have not been analyzed. Our analysis focuses first on three technology-enabled business that scaled rapidly in India. We begin with Telcos and Broadband.

1) Case I. Airtel (Telcos and Broadband)

Telcos in India have witnessed rapid growth over the last decade, driven primarily by rapid increase in mobile subscriber base. Teledensity (the number of telephone lines for every 100 people in a country) in India has increased from 18.3 in FY07 to 92.6 in FY17, a five-fold increase over a span of 10 years. The Total number of mobile subscribers increased from 635.1m in June 2010 to 1210.84m in June 2017. This includes standard feature phones and smartphones. A far more interesting phenomenon presents itself when we look at the smartphone adoption rates in India.

International Data Corporation (IDC) predicts India to overtake US as the second-largest smartphone market globally by 2017 and to maintain high growth rate over the next few years as people switch to smartphones and gradually upgrade to 4G2. Ericsson Mobility Report India predicts that smartphone subscriptions in India are expected to increase four-fold to 810 million users by 2021, while the total smartphone traffic is expected to grow seventeen-fold to 4.2 Exabytes (EB) per month by 2021.

The Indian telecom growth story documents how technology developed and tested in a developed market can be deployed to emerging markets that have a wide user base, while the original cost of developing the requisite hardware, software, protocols and standards is absorbed by high-relative income developed markets. Figure 2 below demonstrates the

timeline and milestones of the Indian telecommunications (telecom) and broadband sector

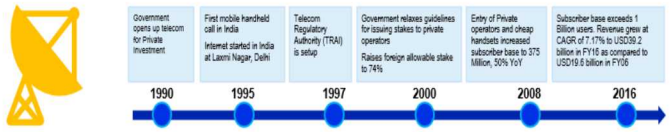

Fig. 2. The telecom industry in India.

2) Case II. Digital Payments (Times of Money)

Digital payments (Figure 3) is one of the fastest growing technological disruptions in India with a combination of technology enablement (availability of smartphones and high speed data networks), consumer knowledge, and government policy driving penetration. The widespread adoption is driven in part by rapid technological investments in the sector by private players and widespread onboarding programs being rolled out to merchants and retailers, bypassing traditional onboarding programs of legacy digital Point of Sale (PoS) systems. In the age of widespread smartphone device penetration and high-speed data availability, anyone with can become a merchant within a matter of minutes. Digital payments also received a big push when the Indian government rolled out its demonetization policy in 2016, rapidly driving up digital payments across an ecosystem that was already put in place a few years back through private investments and ventures.

Post-demonetization in 2016, the number of total transactions increased from 138.09m in Nov 2016 to 261.67m in Jan 2017. As of July 2017, the number of total mobile wallet transactions stand at 221.63m. The total transaction value of mobile-wallet based transactions also increased from 3305 INR crores in Nov 2016 to 8353 INR crores in Jan 2017. Transactions based on Unified Payments Interface (UPI), a direct account to account transfer system, increased from 100 INR Crores in Nov 2016 to 1659 INR Crores in Jan 2017. Figure 3 below demonstrates the timeline and milestones of the Indian Digital Payments sector.

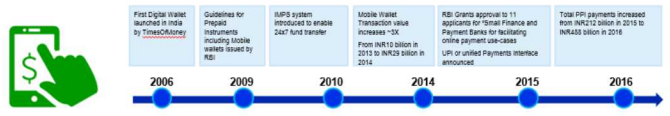

Fig. 3. Digital Payments.

3) Case III. Aadhar

Aadhar, meaning "foundation" is a biometric identity system, established to ensure that all people living in the country are documented. The fundamental use case for Aadhar is to roll out Direct Benefit Transfer (DBT) schemes to the broader populace and avoid the intermediary costs borne by the exchequer. From covering 4% of the population in 2011 to nearly 82% in 2016 and 99% in 2017, the system is used to roll out many Direct Benefit Transfer schemes including Unemployment and LPG Benefits.

The system was launched in 2009, is the largest biometric identity system in the world with over 1.171b enrolled members as of 15 Aug 2017. As of this date, over 99% of Indians aged 18 and above had been enrolled in Aadhaar.

World Bank Chief Economist Paul Romer described Aadhar as "the most sophisticated ID program in the world." Aadhar has scaled rapidly post implementation, driven primarily by government policy. Figure 4 below demonstrates the timeline and milestones of Aadhar program in India.

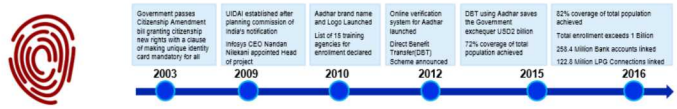

Fig. 4. Aadhar

A common theme to all these high growth tech enabled offerings is that they all went through a government policy-based initiation, regulation enablement and wide scale roll-out cycles. It is important to note the contrast these roll-outs have had to developed markets, where program initiation is primarily private sector driven. Infrastructure development, R&D funding and commercialization for next generation technology in developed markets is also driven by private sector investments. Government policy and initiation is usually introduced later into the market and many times there is no policy decisions introduced at all, leaving the private sector to navigate market dynamics & competition while balancing consumer demand.

B. Unsuccessful Cases

Emerging market economies and emerging technology-based startups generally have high hurdles [64]. Most persistent startup efforts learn more from other firm failure than they do from success [64], [65]. It is often hard to obtain secondary data sufficient enough to develop case studies, but it is of interest nonetheless.

Here we discuss three companies that embraced emerging IoT markets and failed. They are Wallet365 by Times of India, The Agriculture Intel Digital Kiosk, and the Aakash Tablet. These cases demonstrated that "being early to the market" in emerging markets can mean death by: regulation, consumer friction or lack of clear-cut consumer value recognition. This can happen regardless of the size of firm involved.

1) Case IV. Aakash Tablet

The genesis of the of the Aakash Tablet stemmed from an earlier project carried out by the Bangalore-based CSPU to produce a low cost "Made in India" computer that would bring digital computing capabilities and benefits to children in rural areas. The business model revolved around government subsidizing the production runs with in-sourcing and economies of scale. Furthermore, the cost for the tablets would come out of individual budgets of the participating institutions, albeit at subsidies granted by the government. The original "Simputer" was produced between 2002 – 2007 by Bharat Electronics Ltd. with a production run of 5000 units.

Subsequently, in 2011, the government, transformed the low cost computer targeted at underprivileged children into a

tablet project and targeted the urban college going youth with their "Aakash Tablet" initiative. The government initially announced price per unit of the tablet to be at $35, however, 9 weeks after the initial announcement, the product that was launched was re-priced to $60 with lower specifications and capabilities.

The device was developed to target nearly 25,000 colleges and 400 universities as part of a broader e-learning initiative. The contract to manufacture was secured by British-Canadian vendor Data-Wind. As of February 2012, DataWind had over 1,400,000 pre-orders, but had only shipped 10,000 units – 0.7% of orders. Despite global trends in technology reshaping education [66] and large demand, the company was not able to meet the opportunity.

2) Case V. The Agriculture Intel Digital Kiosk

The state governments in India have a tradition of generating rural internet kiosks. Many have been generated under different monikers with the aim of empowering the rural citizens. The are focused on providing internet connectivity and in turn having rural citizens benefit from additional information sources. Chief amongst the proposed use cases included but were not limited to:

1 - E- Governance

2 - Agriculture Consultancy & Veterinary

3 - Remote Health-Care Consultancy

4 - Entertainment

5 - Education & Employment News Portal

6 - Rural Data Collection

7 - Remote Learning

Different state governments had different end-vendors working on different initiatives with many private vendors participating in the process of developing these kiosks in coordination with government educational institutions like IIT-Madras for developing the core technology. The proposed revenue for the initiative was expected from services availed through the kiosk. A detailed list of the different services and their rate list was provided at the kiosks themselves. On average, each kiosk was expected to generate around Rupees 48,000 in revenue per year, through numerous services, with an upfront investment of Rupees 75,000.

One of the initiatives launched in 2000 was Gyandoot, by the government of Madhya Pradesh, that had won the prestigious Stockholm Challenge award in 2000. However, according to Richard Heeks' "ICTs and the MDGs: On the Wrong Track?"and Monica Raina's "Electronic Government and the Rural Poor: The Case of Gyandoot" the project was considered a failure.

According to the "A Critical Study on Role of Gyandoot Intranet Project in E-governance in Madhya Pradesh" survey, 2009 and "Centre for Electronic Governance, Indian Institute of Management, Ahmedabad" report, community engagement figures for the initiative remain extremely low with usage statistics. Citing directly from IIM- Ahmedabad Report:

"The CEG-IIMA study team could not locate any users at the Gyandoot soochanalays (in the Dhar town as well as in the nearby village) on the day of the exploratory visit. Even the logbooks maintained at the soochanalays displayed low usage statistics (10 to 12 users for driving license, certificates, and mandi prices, for the month of April 2002), indicating a very poor turnout of citizens during past several months. For most of the day, on the day of the exploratory visit, the power supply was off at some of the soochanalays."

3) Case VI. Wallet365

This "Digital Wallet" was launched by Times of India in 2006. It had a short life. It was shutdown in the few weeks post launch by RBI for violation of RBI guidelines regarding 'acceptance of deposits' for a non-banking entity. The concept was sound and some see a corporate success story that was successful.

The Wallet365 service was an exact copy of the Global PayPal service. This digital wallet-enabled service allowed customers to transfer money electronically with participating digital wallet owners on a common platform. The back end to the platform or the payment gateway was serviced by Yes Bank. The revenue model for these services was built around the payment providers taking a percentage cut from the merchant, for the digital payment services offered, in line with established processors like VISA, MasterCard, Maestro etc. According to an IMRB Report, I-Cube Report 2014 report, in 2010 alone, the revenue opportunity, for e-commerce and subsequently digital payments, stood at 26,263 Crore Rupees for the year 2010.

IV. Findings

A. Key drivers for large scale IOT technology infrastructure service base adoption in emerging markets

We provide our findings for both the successful and unsuccessful firms. We find support for our key drivers both by their presence in successful firms and one or more of their absences in unsuccessful firm in the case of emerging markets. The key drivers are:

Government Policy

Private Sector Enablement

Technology Availability

Revenue Opportunity

Customer Education

We first discuss lessons learned from successful firms followed by learning from failure.

B. Learning from Successful Firms

We provide our findings via a table followed by a short discussion on how the firms responded to each driver. Our focus on learning from successful firms is provided in Table 2. We provide for each of our three success stories the results of our analysis of the state of drivers for different high tech driven offerings at the time of roll-out and how they were subsequently enabled for widespread adoption:

	Government Policy	Private Sector Enablement	Technology Availability	Revenue Opportunity	Customer Education	Outcome
Aadhar	Formulation of key policy framework and implementation body with strict deadlines	Core tech and implementation developed through private sector contracts. Later opened up to everyone via IndiaStack	Presence of cheap bandwidth, biometric electronics and cloud computing infrastructure	Initially developed to develop unique ID. Extended to remove operational friction and save money in DBT schemes	Education of implementers handled through assigned agencies trained by private partner. Aadhar benefits actively marketed	One of the fastest initiatives in the world to scale to 1 Billion end users
3G/4G/5G	Initiated by TRAI by auctioning of spectrum. Ensured fair pricing of data and voice services	Bulk of 3G/4G spectrum sold to both domestic and foreign private players	In-Line with global 3G/4G infrastructure rollouts and handset availability	Direct and Indirect revenues through servicing over a Billion customers through connectivity and VAS	As of 2016, when 4G networks became mainstream, India had 264 Million Smartphone users	Total Mobile Data Payload increased from 26 Pbytes in 2012 to 128 Pbytes in 2015 and 165 Pbytes in 2016, post mass market 4G rollout
Solar	First country in the world to setup a dedicated ministry for non-conventional energy	Project developers exempt from tax for the first 10 years of operation Preferential tariff for renewable energy sources	In the last few years, the cost of solar PV panels has decreased dramatically. Solar technology is currently cheaper to run than fossils	Primary revenue in solar is currently from CAPEX model. Installed Capacity for 2017 is 12,163 MW, from 2650 MW in 2014	Installed by professionals for commercial projects.	One of the fastest growing solar industries in the world. 5.525 GW added in 2016-2017 with plans for 100 GW by 2022

Table 1. Successful firms deployed the key drivers.

Based on our observations, success in hyper-scale projects requires government policy action to seed the firm through central-government policies and initiation. It is to be noted that successful projects share the following driver characteristics:

Government Policy - Should be part of broad-based government policy, preferably a long-term initiative, driven by a representative ministry or planning commission assigned body

Private Sector Enablement - Private sector should be allowed to participate through both domestic and foreign investment and suitably incentivized

Technology Availability - Mass market technology capability that is proven on the global scale or with successful pilot programs in the global arena

Revenue Opportunity - Identify clear end use cases for both one-time and recurring revenue opportunities. Government should also contribute, wherever possible through suitable incentives

Customer Education - Identify use cases that require minimal education and tap the increasing smartphone savvy Indian populace. Implementation should be accompanied by on device training

C. Learning from Unsuccessful Firms

We provide our findings from unsuccessful firms via a table followed by a short discussion of more specific issues expressed in each case. Our focus on learning from unsuccessful firms is provided in Table 2. We provide for each of our three failed firms the results of our analysis of the state of drivers for different high tech IoT service technology driven offerings at the time of roll-out and how they were subsequently unable to generate widespread adoption. In each failed case a lack of suitable business models, technology and fragmented-government support lead to firm failure. These firms share the following driver characteristics:

Government Policy - Ideally, should not be a fragmented-government initiative. Initiation by standalone organizations usually leads to operational inefficiencies in implementation

Pvt. Sector Enablement - Private sector should avoid using traditional operational channels as they lead to inefficiencies and delays in permits, operational licenses etc.

Technology Availability - Unproven and custom technology should be avoided as most equipment operate under harsh conditions. Furthermore, repair costs are a major barrier

Revenue Opportunity - Revenue models that seek to offset costs through cash payments collected at individual touchpoints should be avoided

Customer Education - Should not depend on lengthy courseware and use of non-traditional user interfaces to be avoided

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	Government Policy	**Private Sector Enablement**	**Technology Availability**	**Revenue Opportunity**	**Customer Education**	**Outcome**
Digital Education – Aakash Tablet	In order to broadbase digital education, the government launched the "Aakash" Tablet Scheme.	The manufacturing and order fulfillment for the $35 tablet was outsourced to private entity DataWind	Due to the $35 target price, under-powered components were used that led to poor performance & usability issues	Revenue opportunity was expected through government orders. However poor reception and inability to fulfill demand led to low final sales	Planned to train over 10,000 teachers through digital learning were developed, but poor reception and connectivity issues prevailed	As of 2015, the new BJP led HRD ministry pulled the plug on the Aakash initiative. In a 2017 interview the ministry quoted that there were no plans to revive the project
Agriculture Intel Digital Kiosk	Initiated by IIT Madras. Concerned govt. dept. expedited kiosk permits. Some state governments extended support as part of e-governance initiative	As the policy was not driven by government, minimal enablement of private players. Operator had to use traditional channels	Core technology was CorDECT developed by IIT Madras and tested in global pilots through collaboration. Some operators also used off-the shelf technology	Although revenue opportunity per kiosk was low, the aim of servicing 70% of the total Indian populace, theoretically made it a high volume business	Minimal customer education would be required as kiosks would be operated by a dedicated operator	According to Abdelaal, average operating costs were about INR 3000 PM for each Kiosk-Operator and low revenues led to many KOs folding in 2007
Early Digital Payments	Initiated by private players to facilitate and cash-in on the growing e-commerce industry in India	At the time, no regulations or policies existed to govern the digital payments industry. RBI clearly stated, no third party was authorized to process payments and shutdown players	Technology enabling the same was already present and used by international players, who had implemented similar systems abroad	Revenue opportunity to service the booming digital commerce in India was huge. According to an IAMAI report, in 2010, the revenue opportunity was > 26,000 crore Rupees	Some customer education was required for circumventing the issue of trust and security of online transactions for first time users of the system	The regulatory authority immediately shutdown all offerings in that time period, despite the large market, for a lack of regulation

Table 2. Learning from failure.

1) The Aakash Tablet/OLPC Initiative

The failure of the project was underpinned by multiple factors, chief amongst which were the low target price, poor specification, and no singular project ownership and co-ordination of the broader e-learning initiative.

Low Target Price – The tablet initiative was initially priced at $35, however final landed cost of the tablet was $50. Given the distributed nature of assembly of electronic products and no subsidies provided to local players for local assembly, the project had to be outsourced to DataWind instead of being developed within the country. This led to last generation components to keep costs within check and resulted in user experience that could barely keep up with the then state of the art. Additionally, a very rudimentary set of software and e-learning tools were available pre-loaded, that further limited usability

Technology Comparison to State of the Art – It is widely agreed that the Apple iPad was one of the leading tablets in 2012 and to a large extent in the present day. Apple is known for using last generation hardware and marrying it to state of the art of software optimizations for a highly polished user experience. Even though the Aakash tablet was never a direct competitor, a comparison of the specs of the devices for the same year clearly shows how far behind the Aakash Tablet specifications were, compared to Apple's 2012 iPad. The Aakash Tablet had a Single Core 366 MHz Processor mated to

256 MB of RAM, 2 GB ROM and a 2100 mah battery. By comparison, a base level iPad in 2012 had a Dual Core 1 GhZ Processor, 1 Gigabyte of RAM,16 GB ROM and a 11560 mah battery. Even the budget options of the time like the Kindle Fire 2012 had a Dual Core 1.2 GhZ Processor, 1 GB RAM and 8GB ROM and a 4400 mah battery. In-order to fulfil the cost requirements set forth by the Indian Government, DataWind had to put in hardware specifications that were at a minimum, 2 generations behind the state of the art, leading to an extremely poor end-user experience that was widely criticized by reviewers and initial users

Program Ownership – The initial design draft was conducted by IIT Rajasthan, however they wanted to have additional features and higher specs. The program was subsequently shifted to IIT Mumbai, IIT Madras and IIT Kanpur for specification drafting. However, the requested specifications could not be met owing to higher procurement costs and mild support by participating institutes in contributing to the procurement costs, and lackluster support by the wider government body. At the time of the specification draw-up, it was suggested that 35% of hardware components were to be sourced from South Korea, 25% from China, 16% from the USA, 16% from India and 8% from other countries. However, DataWind, the final contractor of the tablet had to finally self-procure components from Chinese subsidiaries to meet the target price. Furthermore, the software development initiatives for the tablet were restricted to competitions for developing apps that would ship alongside the tablet and no training/development and content initiatives being part of the original software that shipped along with the tablet. The inability to install third-party software further limited the capabilities of the tablet.

2) The Agriculture Intel Digital Kiosk

The failure of the project presented itself with the service technology infrastructure portion of the service product. We highlight two infrastructure technology issues. Further we provide a revenue problem.

Connectivity - The internet kiosks or "Soochanalays" had access to the internet via two primary technologies, Dial-Up and CorDECT. Out of the 38 kiosk surveyed, 31 had dial-up connectivity, which had frequent slowdown and connection termination issues. The CorDECT technology was touted as a better performer, however the cost per implementation was higher and hence the lower penetration. As per the report "To introduce WiLL in Dhar, the Gyandoot Samiti has registered itself as a Local Service Provider (LSP) nLogue Communications, India. The cost of installation of WiLL technology for connectivity to locations within a 25 km radius from the head quarters is Rs .7.5 Lacs. This service would become viable only when the number of soochanalayas goes up dramatically (from the current level of 7) or the connectivity is extended to more citizens as telephone service". Another part of the report cites "In about 50% of the soochanalayas surveyed, connectivity is not available on a regular basis. 5 soochanalayas do not have connectivity yet to Gyandoot server, in spite of being registered for almost 2 years"

Power Supply - Power supply was infrequent and unreliable back in the 2000s for Urban India. The effect was compounded manifold in rural india, the primary deployment base of the Internet kiosks. Many operators reported frequent and long power cuts that halted the operation of the information kiosks on a day to day basis, with no clear service delivery timings. As per the Gyandoot project report by IIM - Ahmedabad, all off the surveyed kiosks reported at-least 6 hours of power outage with breakdowns extending to 3 - 4 days on occasion. Even at the time of the survey being conducted, 35% of the kiosks did not have power with 10% indicating they had outages for more than a day in the past'

Revenue Generated - Of the sample set available of 18 kiosk operators or soochaks, the total revenue generated stood at Rupees 65,200 over a period of two years, or Rupees 150 per kiosk or soochanalay. These revenues were too low to encourage sustained operations. As per the cost breakdown, expected revenue per kiosk was pegged at Rupees 48,000 per year, in addition to an upfront establishment cost of Rupees 75,000

3) Wallet365

This case highlights the importance or regulatory bodies to an emerging technology-based IoT firm. We name these government policy based issues. We provide two here.

Policy based Shutdown - Within a few months of operation and despite relatively positive uptake amongst customers, these digital payment platforms were shutdown under order by the Reserve Bank of India. It is to be noted that the primary reason for shutting down of these entities was lack of regulatory guidelines for governing digital payments using a third-party processor. The legal accepted tenders were issued to the banks by the RBI and a third processing entity was outside the purview of the current policies and regulations. It is to be noted that at the time of shutdown, Wallet365 had 85,000 registered users

It is notable that in the absence of regulations, banks could not provide e-wallets or even mobile payment facilities. Some banks even went to the extent of completely disregarding the regulations, in order to build market share, and went ahead with their service launches. For example, ABN AMRO Bank tied up with mobile-payments provider PayMate to provide its customers with mobile payments and ticketing services. Max New York Life joined hands with mChek (powered by Citibank) to policyholders to pay their renewal premiums.

Then, on 22nd July of the same year, RBI issued a circular specifically barring banks from launching such schemes until it issued formal regulations. RBI made it categorically clear to banks that all payments are part of its regulatory domain and they cannot launch products without its clearance

New Policy Formulation - Shortly after the shutdown of these players in the market, the government began formulating policies for rolling out digital payments to the mainstream. In 2009, the government began looking at prepaid cashcards (PPI) and subsequently led to the handing out of the PPI Licenses in 2010 to some entities. However, it was a good 8 years later, in 2014, that the government rolled out the digital payment bank policies, keeping in line with the digital India initiative and trying to ride the wave of digital commerce in India.

V. Discussion

Based on our findings, we provide a summary table (Table 3) that provides areas and target audience groups where the current state of a particular emerging market can be leveraged. The table below has three customer segmentations and shows the state of the different enablers for these customer segments.

	Government Policy	**Pvt. Sector Enablement**	**Technology Availability**	**Revenue Opportunity**	**Customer Education**
Applicable to all Citizens	Current Policy is focused on: -Digital Identity & Payments --Removing Gasoline Vehicles by 2030	-Auctioning of M2M spectrum -Foreign Direct Investment % increased	-Low Cost Connectivity -Low Cost Sensor -Low Cost Platform Services	-Service Revenue from Serving 1B+ potential end users	-As of 264 Million + and growing smartphone savvy users
Applicable to SMEs and Industries	-Renewable Energy & Energy Self Sustenance -SME Loan Enablement	-SEZ Creation & Enablement -Online government Tendering -Online Government E-Procurement	-Next generation Industrial Automation	-SME and MSME manufacturing & services contributed nearly 30% to GDP as of 2015	-NA
Applicable to a niche or Luxury Market	-Luxury Goods and Assembled still face high taxes as government promotes "Make In India"	-No Major changes	-NA	-NA	-NA

Table 3. Customer segmentations.

VI. Conclusion and Future Research

We provide and test an emergent model for successful disruptive service technology-based (IoT) firm formation. We demonstrate that firms based on IoT technology are uniquely positioned to drive a diverse set of use cases in emerging market economies utilizing our key drivers and business models. Just as the advent of low cost mobile 3G/4G data initiated many businesses in India, the arrival of IoT technologies and supporting development ecosystem will open up a plethora of use cases across sectors like environmental monitoring, energy, agriculture, health & disease management, and many others.

We observe that, at least in the Indian emerging market ecosystem, emerging technologies must have a low cost entry. As emerging markets are exposed to innovative technologies that have benefited from cost reduction in R&D through developed markets, interest for adoption grows. This interest in turn is further fueled by policy changes that enable private/public players to leverage the services angle and churn out highly outcome driven use cases and solutions. A combination of outcome driven solutions, government policies and low cost of the technology being used thus enable emerging markets to leapfrog mature markets. This presents a very unique technology lifecycle, where a bulk of the R&D costs are absorbed by developed countries, while the service revenue benefits and use of the products by the SIs happens in emerging markets. This analysis holds true for many modern-day innovations like the Smartphone, Digital Payments and Internet Connectivity.

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