Telecommunications Policy 41 (2017) 473–485

Contents lists available at ScienceDirect

Telecommunications Policy

journal homepage: www.elsevier.com/locate/telpol

Framework for evolving spectrum management regimes: Lessons from India

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ARTICLE INFO

Keywords:
Spectrum management
Market orientation
Command and control
Transition
Spectrum assignment
Spectrum allocation

ABSTRACT

India has seen a marked change in spectrum policy over the past decade from a legacy administrative regime to a more market oriented one wherein it has adopted auctions in the primary market, trading in the secondary market and has liberalised spectrum to make it technology and service neutral. It has faced numerous challenges, constraints, and legacy issues in its transition, thus providing a rich context for analysis. Using the case study of India, we developed a framework that highlights the various dimensions to be considered while migrating from an administrative to a market regime for spectrum management. The framework also helps to assess the current orientation of a spectrum policy regime and provides a direction for adopting a higher market orientation. We used the framework in the Indian context to show that while India had adopted market mechanisms, it had a low level of market orientation.

1. Evolution of spectrum management regimes

Rapid changes in wireless technologies and their accelerated commercial adoptions have seen an evolution of most national spectrum management regimes from pure administrative command-and-control institutional arrangements to more market oriented ones. This adoption of market based practices has often been a part of a larger deregulation process wherein countries have transitioned from state monopolies to increased private participation in telecom service provision.

Transitioning from an administrative to a market regime for spectrum management is a complex process as it involves intricate planning and foresight coupled with challenging legacy issues in implementation. Such complexities are magnified manifold for emerging economies which have weak institutional structures and capabilities (Horowitz, 1989; Jain, 2014; Thiruvengadam & Joshi, 2012). To deal with the complexities, transition to market regimes is often phased and incremental. However, the transition in emerging economies is fraught with challenges as their response to unforeseen emergent situations is often ad hoc. While there are several case studies of developed countries regarding issues in transition from an administrative to a market regime (Bohlin, Blackman, Forge, & Renda, 2007; Kwerel & Williams, 2002; Minervini, 2014), there are few that cover these issues from an emerging economy perspective (Hazlett, Giancarlo, & Wayne, 2007; Minervini, 2014).

India represents a unique and rich case study in this regard. Its telecom industry is characterized by small fragmented spectrum assignments, high competition, low rural penetration, and heavy dependence on wireless telecommunications by over 97% of its subscribers (TRAI, 2016). It has seen a marked change in spectrum policy over the past decade from a legacy administrative regime to a more market oriented one wherein it has adopted auctions in the primary market, trading in the secondary market and has liberalised spectrum to make it technology and service neutral. It has faced numerous challenges, constraints, and legacy issues in its

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http://dx.doi.org/10.1016/j.telpol.2017.04.002
Received 31 May 2016; Received in revised form 24 March 2017; Accepted 4 April 2017
Available online 18 April 2017

transition, thus providing a rich context for analysis.

2. Objective

We aim to develop a framework that may be used as a theoretical lens for examining the spectrum policy regime in India and its phased transition to a market oriented one. The objective is to provide a structured framework that helps analyse the challenges faced by India and thereby provide useful insights for regulators in other developing countries. This framework may be used as an assessment tool for the current level of market orientation and a guide for future planning.

3. Literature review

Administrative regimes have limited information regarding localised needs and emerging technologies leading to inefficient assignments and allocations (Coase, 1959; Hazlett, 2008; Spiller & Cardilli, 1999; Valletti, 2001) and place high discretionary power in the hands of the administrator sometimes leading to issues of corruption and transparency (Sukhtankar, 2015). A key objective of regulatory reform in the transition to market regimes has been to provide flexibility to operators to make choices regarding spectrum use and technology while balancing concerns of market failures with respect to universal coverage and competition. Market regimes entail assignment of spectrum in the primary market through auctions, development of secondary market for trading, leasing and sharing (Bykowsky, 2003; Crocioni, 2009; Farquhar & Fitzgerald, 2003; Jain, 2010) and keeping spectrum technology neutral while ensuring that interference remains manageable. Auctions ensure that the owner of spectrum does not have any windfall gains while assigning it to operators who value it the most and seek to derive the highest utility. The secondary market allows spectrum to be reorganised according to size and use with evolving market needs and technology.

However, market regimes suffer from market failures (Cave & Pratt, 2016; Freyens, 2009; Peha, 2007) such as inability to internalise positive externalities, high transaction costs, uncertainty, coordination failures, information asymmetry and risk aversion (Freyens, 2009). As an example of a positive externality, the European Union's administrative harmonisation of GSM across the 900 MHz and 1800 MHz band allowed operators to internalise network effects of large scale adoption leading to lower costs and inter-operator and inter-country portability (Sutherland, 2006). In comparison, USA did not harmonise spectrum during the same time period leading to fragmentation of its market as a result of which devices were not as affordable, and could not roam on foreign networks in the early period of mobile services (Bach, 2000; Pelkmans, 2001). There have also been administrative interventions at harmonisation that have failed in case of technologies with little demand. For example there has been limited success for TETRA mobile services in Europe that were harmonised in the 870–876/915–921 MHz band (Cave, Minervini, & Mfuh, 2008).

3.1. Migration to market regimes

Studies that have examined the transition from command and control to market regimes have largely focused on deregulation of assignment and allocation (Jain, 2010; Kwerel & Williams, 2002; Minervini, 2014). The literature on deregulation of assignment covers introduction of auctions in the primary market and trading in the secondary market (Cramton & Ockenfels, 2014; Jain, 2010; TRAI, 2012). The literature on deregulation of allocation covers a variety of instruments to bring in flexibility in technology and service provision (Pahl, 2006; Pratt & Bellis, 2006; Ramsdale, 2005).

Several countries have adopted auctions for assignment including US, UK, Canada, Germany, France and India (Cave & Webb, 2015; Cramton & Ockenfels, 2014; Jain, 1999; Prasad & Sridhar, 2014; Taylor, 2015). A number of studies have examined different aspects of auctions and their design including reserve price, total supply and block size, and examined how these factors influenced policy outcomes and strategies of operators in their countries (Bichler, Goeree, Mayer, & Shabalin, 2014; Cramton & Ockenfels, 2014; Cramton, 2013; Prasad, Kathuria et al., 2014).

Deregulation of assignments has been accompanied by creation of secondary markets in several countries (Bohlin, Preissel, Weber, Xavier, & Ypsilanti, 2006; Crocioni, 2009; Farquhar & Fitzgerald, 2003). For example, UK permitted trading in 2004, gradually increasing the number of licenses that could trade their spectrum (Akalu & Diaz Arias, 2012; Minervini, 2014). USA has promoted a variety of instruments such as leasing, sub-licensing, easement (Force, 2002). Australia introduced Standard Trading Units that define the geographic area and band that may be traded (Commission, 2003). The scope of trading varies across different countries in terms of amount of spectrum, geographic area, life of license, and permitted buyers (Bykowsky, 2003; Crocioni, 2009; Farquhar & Fitzgerald, 2003; Minervini, 2014).

For bringing flexibility in allocation, a variety of instruments have been analysed in literature. UK introduced technology flexibility using Spectrum Usage Rights (SUR) that specify the levels of interference that a licensee may cause, without specifying the levels of transmitted power (Cave & Webb, 2012; Minervini, 2014; Webb, 2009). Notably, while Ofcom has been studying SUR for many years, the actual issue of licenses with such SUR has been limited (Cave & Webb, 2015). On the other hand, USA specifies the limits of power radiated, thus limiting the technology choices available (Hazlett, 2008; Kwerel & Williams, 2002). The EU has recommended facilitating the coexistence of different types of licensing models and review of the use of government and military spectrum for commercial purpose (Delaere, 2007; RSPG, 2010). In several other countries, the type of service that may be offered is tied to the specific band. For example, Indian operators were required to provide GSM voice services in the 900 and 1800 MHz band (Jain, 1999, 2010; Sridhar & Prasad, 2011). With advances in technology, and mobile services, especially 3 G and LTE becoming available in various bands, a number of regulators have switched to more service and technology neutral licensing (Pahl, 2006; Pratt & Bellis, 2006).

Literature has often treated administrative and market regimes as a dichotomy while discussing the merits of migrating to market regimes and has remained largely silent on the path for transition. Freyens (2009) attempts to break the dichotomy and sketches a 'spectrum of spectrum regimes' that highlights various mixed regimes. By examining six dimensions of property rights, Freyens suggests 16 types of hybrid spectrum management regimes that are feasible. These six dimensions where regimes make choices are:

(i) Technology flexibility: has two attributes (yes, no) and refers to whether there are any regulatory constraints on the technology to be used in a band.
(ii) Usage flexibility: has two attributes (rigid, flexible) and refers to whether there are any regulatory constraints on the designated use of a band such as broadcasting, cellular and WiFi.
(iii) Rights exclusivity: has three attributes (full property rights, eased property rights, collective use) and refers to the exclusivity in rights of usage. The three attributes can be re-interpreted as exclusive, semi-exclusive and non-exclusive.
(iv) Rights assignment: has three attributes (administrative licensing, auctioned and tradable, unlicensed) and refers to the type of licensing regime. In this, auctioned licenses are considered equivalent to pure property rights over spectrum and can be traded in the secondary market.
(v) Club membership: has two attributes (yes, no) and refers to whether shared bands have limited or unlimited membership. This attribute is not applicable for arrangements with exclusive rights.
(vi) Rules control: has two attributes (self control, government managed) and refers to who is in-charge of establishing the rules for appropriation of spectrum.

Minervini (2014) identifies two major areas of deregulation for transitioning to market regimes. The first is called deregulation of assignment (DASS). This refers to switching to auctions in the primary market and trading in the secondary market. The second is called deregulation of allocation (DALL). This refers to liberalisation of spectrum by which the band user is given flexibility to adopt a service and technology of choice. Minervini (2014) compares the gradual transition of Anglo-Saxon/European countries with the big bang transition by Central American countries. The author suggests that the outcome of any big-bang reforms is likely to be unpredictable because of information uncertainty in dealing with legacy issues. In comparison, the gradual approach is preferable as it helps reduce uncertainty and provides an option of reverting to the earlier state.

While the frameworks used by Minervini (2014) and Freyens (2009) provide a theoretical basis for analysing transitions, they are limited by the number of dimensions of property rights they consider. For example, Minervini (2014) only examines deregulation of allocation and assignment, while suggesting that liberalisation in assignments have preceded those in allocations. The focus of the paper has been on speed and sequencing of spectrum reforms. On the other hand, while Freyens (2009) considers more comprehensive dimensions in spectrum management regimes, this is not done in the context of pathways for transitioning to a market regime. Freyens (2009) also misses out on some important elements of property rights and does not adequately deal with the nuances relevant to developing countries such as roll-out obligations and delinking of auctions in primary market from tradeability in secondary market. We feel that a more nuanced approach with a strong foundation in theory that captures the reality of developing countries could help in analysing the transition in a more comprehensive manner.

Towards this end, we propose a new framework that brings theoretical structure to the evolution towards market regimes by various countries. We use this framework to bring structure to India's approach and the legacy issues faced by it. As a related contribution, we show how this framework may be utilised for assessing the current level of market orientation of any spectrum regime to identify the policy options for transitioning to a greater market orientation. In this regard, this aspect of the framework provides a possible path for implementation.

4. Methodology

We adopt the single case study approach in this paper (Willis, 2014; Yin, 2009). Specifically, the study explores the case of India's spectrum management policy between 1994 and 2015. The primary sources of data for the case study were consultation papers and recommendations by the Telecom Regulatory Authority of India (TRAI) and directives by the Department of Telecom (DoT) published on their respective websites. These documents are very detailed and extensively document the historical institutional context and the reasons for decisions. We first examined this data from the lens of existing frameworks proposed in literature. We reviewed the shortcomings of existing frameworks and used those as guidance to develop a new framework that is able to capture the complexities of India's spectrum management regime.

We operationalised the case study by using an iterative coding process (Holton, 2007; Jenkins-Smith & Clair, 1993). We analysed incremental changes in India's spectrum management approach every year from 1994 till 2015. For each change identified in a year, we first checked whether it belonged to an existing coding dimension or whether a new entry had to be created for it. If it belonged to an existing dimension, we listed the evolved status of policy for that year with respect to the year before that. Each time we encountered a new type of change to India's approach, it was listed as an additional dimension in the coding frame. Then the entire process was re-initiated from 1994 to recode the status of policy for the new dimensions. As a result, by the time the final iteration reached 2015, we had identified all dimensions relevant to the transition to a market regime. Further, for each dimension, there was year wise data of status of policy to understand India's phased transition. Whenever there was a change in the identified dimensions, we also noted the legacy issues faced in the transition. The framework developed using this approach only reflects those dimensions considered in India's transition to a market regime. Other jurisdictions may have considered additional aspects for a

transition to a market regime that should be added to the framework by future researchers by extending this process to other case studies.

In Section 5, we describe India's evolving spectrum management regime between 1994 and 2015. In Section 6, we present our analysis of the case study based on existing frameworks and critique the emerging analysis. In Section 7, we propose a new framework for planning and implementation which attempts to address the shortcomings identified in the previous section. In Sections 8 and 9 we present our contributions and conclusion.

5. Introduction to India's evolving spectrum management regime

5.1. The legacy administrative framework (1994–2010)

In India, the Department of Telecommunications (DoT) is the licensing authority that grants licenses to telecom operators for providing communications services. The Wireless Planning & Coordination Wing (WPC) of the DoT develops and manages the National Frequency Allocation Plan. This plan is harmonised as per ITU recommendations for Region 3. The WPC along with the Telecom Enforcement, Resource and Monitoring (TERM) Cells continuously monitor and provide clearances for all new wireless installations in the country.

India's approach towards private telecommunications was first announced in the National Telecom Policy 1994 in which only a duopoly between two private cellular operators was allowed. Subsequently, the DoT assigned two licenses via a beauty parade in each of the lucrative metropolitan circles[1] for provision of cellular services using GSM technology in the 900 MHz band. From 1995–1998, the DoT switched to single stage auctions for assigning two telecom licenses in each of the non-metropolitan circles.

A third government operator and a fourth private operator were envisioned after a revised New Telecom Policy of 1999. In 2001, the Government administratively assigned spectrum to Government owned operators in all circles thus making them the third operators. In the same year, the government also held multi-stage auctions for adding the fourth private operator in all circles. Throughout this period, the spectrum and service licenses were integrated and included only initial 'start-up' spectrum of 4.4 MHz, the minimum amount of spectrum required to start services, with the promise of additional spectrum on a need basis.

After the introduction of private players, the Government recognised the need for an independent regulator. In 1997, the Government created an independent regulator called the Telecom Regulatory Authority of India (TRAI). With respect to spectrum management, TRAI only has recommendatory powers. TRAI provides non-binding recommendations for the consideration of the DoT, which is the executive body responsible for management of spectrum.

As part of the National Telecom Policy of 1999, there were separate licenses for cellular, fixed, cable, national long distance, international long distance, paging and satellite services etc. Private operators for fixed service were licensed to provide the last mile through a wireless loop using CDMA technology in the 800 MHz band. However, they circumvented rules to provide mobile services using the CDMA wireless local loop. To resolve this artificial regulatory distinction between fixed and mobile services, the administrator merged the fixed and cellular licenses into a Unified Access License in 2003, subsequent to a Supreme Court intervention. Around 2007, the government also allowed CDMA operators to get additional spectrum in the 1800 MHz GSM band creating dual technology operators with spectrum spread across the 800 MHz and 1800 MHz bands.

With a rapidly growing subscriber base, there were demands from operators for additional spectrum over their 'start-up' spectrum. The DoT followed an administrative method for this. Often, incremental allocations were not contiguous with originally allocated 'start-up' spectrum. Further, there was no coherent method for determining quantity of additional spectrum to be allocated. Eventually, it got linked to the number of subscribers of an operator. A large number of operators often inflated the number of subscribers by including inactive subscribers to garner more spectrum. The DoT set up several committees, which after many rounds of deliberations came up with an acceptable number of subscribers that could be linked to the amount of spectrum to be allocated. The DoT also notified escalating spectrum usage charges based on spectrum quantity slabs payable to the DoT as a percentage of yearly gross revenue. For example, holding GSM spectrum between 4.4 MHz and 6.2 MHz commanded usage charges of 4% of gross revenue; whereas GSM spectrum between 10.2 MHz and 12.2 MHz commanded usages charges of 7% of gross revenue. These slabs varied for CDMA and GSM technologies.

Between 2004 and 2008, the DoT added over 200 licensees on first-come-first-serve basis using the price determined in the 2001 auctions without any coherent policy on the maximum number of operators. As a result, each circle had approximately 10 licensees. It finally reached a point wherein licenses were allocated but the government did not have sufficient 'start-up' spectrum to allocate to even those who had already been granted licensees. In an attempt to make more spectrum available, both TRAI and DoT continued to tighten the subscriber linked criteria for additional spectrum.

5.2. The transitionary years (2010–2015)

In 2010, the DoT simultaneously auctioned the 2100 MHz band for 3 G services and 2300 MHz band for 4 G services. Three slots of 5×2 MHz each were made available in the 2100 MHz band and two slots of 20 MHz each were made available in the 2300 MHz band. The rollout obligations mandated for the 2100 MHz band were set at 50% of District Head Quarters (DHQs) with the additional requirement that 15% should be in rural areas. The obligations for the 2300 MHz band were to cover 50% of rural Short

[1] Circles are geographical administrative units for managing telecom services.

Distance Calling Areas. Owing to high demand and considerably limited supply with no clear information about future availability of spectrum, the bidding for these bands was considerably high. As a result, these auctions fetched high revenue for the government.

Around the same time, the allocation of telecom licenses by first-come-first-serve in 2008 came under the scanner of the judiciary and investigating authorities for procedural irregularities and loss of revenue to the government. This famously came to be known as the 2 G Spectrum Scam. The valuations derived in the 2010 auctions were used during the 2 G spectrum scam investigations by the Comptroller and Auditor General of India to calculate the presumptive loss caused by the first-come-first-serve assignments in 2008. As a consequence of the scam, the narrative in media was dominated by issues of increasing transparency. Additionally, the scope for revenue maximisation by spectrum assignments gained prominence.

In 2012, the Supreme Court cancelled the licenses granted in 2008 and mandated that spectrum assignments could only be through auctions as it was a public resource that needed to be managed in a transparent manner. An auction-only policy was formally announced in the National Telecom Policy of 2012. The new policy also recognised the need for market related practices for spectrum management including liberalisation, trading, sharing and pooling. The subscriber linked criteria for allocation of additional spectrum was discontinued. The need to migrate to market based practices was further recognised with the rising interest in 3 G and 4 G services. However, the DoT continued to assign backhaul and backbone spectrum administratively as also for captive purposes such as defence, broadcasting etc.

Pursuant to the cancellation of licenses by the Supreme Court, the DoT put spectrum that was freed up in the 800 MHz band and 1800 MHz band up for auctions in late 2012. Until 2012, as part of rollout obligations, operators were mandated to cover only 50% of DHQ for spectrum held in the 800/900/1800 MHz bands. In these auctions, the roll-out obligations for these bands were substantially enhanced to also cover at least 30% Sub-District Head Quarters in addition to 50% DHQs. This was done to increase rural penetration. Using the high auction valuations of 2010 as a benchmark, and paying heed to the media and public sentiment regarding presumed loss of revenue to the government, TRAI came out with a framework where the last auction price would be set as the reserve price of the next one (TRAI, 2012). To find out the relative value amongst bands, it looked at auction prices in different countries, and recommended a multiplication factor vis-à-vis the 2100 MHz band. The factor also considered the relative propagation characteristics across bands. The 1800 MHz reserve price was pegged to the 2010 valuations of 2100 MHz band. The 800 MHz band was valued at 1.3 times.

There were no takers for the 800 MHz band and less than half the spectrum in the 1800 MHz band was sold. The high reserve prices were cited as reason for the same. In subsequent auctions of the 800 MHz band, its valuation was reduced by 50% while that of the 900 MHz was kept double that of the 1800 MHz band. There were no takers for the 900 MHz and 1800 MHz band and only one bidder for the 800 MHz, who bid very close to the reserve price.

In 2014, for the 900 MHz and 1800 MHz auctions, TRAI used a number of methodologies for the reserve price and set it at the average of various methods (TRAI, 2014). This auction saw high bids significantly above reserve prices as licenses of some operators that were issued in 1994 were expiring and these operators had to win back their spectrum to ensure continuity. New entrants seeking to add 5 MHz of contiguous spectrum for LTE services also created competition.

Until 2015, all access spectrum had to be purchased in the primary market through auctions since trading guidelines were yet to be framed. As a result, such spectrum was often not contiguous with originally allocated spectrum and DoT did not take steps to make it contiguous administratively. In the absence of secondary markets, operators functioned with inefficient assignments. This became an issue with the advent of UMTS and LTE that required a minimum of 5 MHz of contiguous spectrum for good data services. To resolve this issue the DoT subsequently initiated an administrative process - spectrum harmonisation - to rearrange spectrum to make it contiguous.

As part of the new policy of market practices, India also migrated to the Unified Licensing (UL) regime in which there was a single license for all services thus creating a service neutral regime. The UL delinked spectrum from licenses. Migration to the UL regime was not made mandatory by the DoT. While it mandated that all spectrum auctioned in the future would be delinked from licenses, it was voluntary for existing licenses to migrate to the UL regime.

In 2015, the government simultaneously auctioned the 800 MHz, 900 MHz, 1800 MHz and 2100 MHz bands. One slot of 5 MHz spectrum in the 2100 MHz band was made available by the Defence Ministry which was previously using it for its communications network. Bidding intensity for the 2100 MHz band was low but most of it was sold except for three circles including Delhi and Mumbai. The spectrum in the 900 MHz and 1800 MHz bands was made available from expiring licenses and also from spectrum unsold from the previous actions. The bidding intensity for these bands was high as incumbents were looking to protect their services to ensure continuity. The spectrum in the 800 MHz band only saw high bidding in circles where contiguous spectrum of 5 MHz was available for provision of LTE services.

With developments in technology, the 800 MHz and the 1800 MHz bands emerged with strong ecosystems for LTE. Keeping this in mind, the regulator initiated consultations on refarming and liberalisation to determine a path to allow operators to migrate to both 3 G and 4 G in existing 2 G bands. After long consultations and considering various options, the DoT approved a policy for liberalising spectrum in 2015. Liberalised spectrum was technology neutral and could be traded in the secondary market unlike its unliberalised counterpart. As part of the policy, all auctioned spectrum would be considered liberalised whereas all administratively allocated spectrum could be liberalised after paying a liberalisation fee. The liberalisation fee was computed as the difference between auctioned prices and administrative prices prorated to the remaining life of the license with the objective of preventing windfall gains in the secondary market.

Under the trading guidelines, trading was only permitted between telecom licensees for spectrum that was liberalised. Only outright sales were allowed. Leasing was not permitted. Block sizes for trading varied for different bands. For example, the block size for trading in the 2300 MHz band was 20 MHz in TDD mode whereas the block size for 900 and 1800 MHz bands was 2×200 kHz. If only a

portion of the spectrum holding was traded, then the entire rollout obligations associated with that spectrum was required to be fulfilled by both the buyer and the seller. A transaction fee of 1% of market valuation was required to be paid to the DoT for all trades.

In 2016, the DoT was considering a multi-band auction for spectrum in the 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2500 MHz bands. The APT700 band plan had been adopted for 700 MHz band. The rollout obligations for the 700 MHz band had been made more stringent than those for the 800/900/1800 MHz bands. Winning operators would be required to cover all towns and villages having population between 15,000 and 50,000 within 5 years and all villages having population between 10,000 and 15,000 within 7 years. Since it was being auctioned for the first time, the reserve price for the 700 MHz band had been set at four times the valuation of the 1800 MHz band on the basis of the rationale that this ratio could be derived from market valuations in European countries that have already auctioned bands with similar propagation characteristics including Germany, Italy and Portugal (TRAI, 2016). Unfortunately, the data used by TRAI had not been made available for public verification and several authors had questioned these calculations (Jain, 2016; Kar, 2016).

6. Analysis

India had a phased transition from a predominantly administrative regime in 1994 to a predominantly market regime in 2015. By then, DoT had adopted auctions in the primary market and permitted trading in the secondary market. Spectrum had also been made technology and service neutral.

This transition was partly driven by changes in technology and judicial interventions rather than as part of a well laid out plan. For example, spectrum was liberalised after the emergence of a strong device ecosystem for LTE across different bands that were traditionally allocated for 2 G voice services. Further, judicial interventions had been a significant driver for adoption of market practices, such as the mandate by the Supreme Court to adopt auctions for assignments to address issues of transparency and corruption. This indicated a lack of strategic perspective within regulatory agencies on viewing spectrum as a key resource for national growth. It reflected a dearth of regulatory capability that could take a forward looking approach.

Even in its adoption and implementation of a market regime, the TRAI and DoT have been faulted by the telecom service providers for numerous reasons. They have argued that TRAI has routinely overvalued spectrum and set extremely high reserve prices, often under the garb of maximising government revenue while not sharing the data used in calculations. Operators have also criticised the government for allocating fragmented non-contiguous spectrum that cannot be used for emerging technologies while still setting high reserve prices using the rationale that such spectrum has been liberalised. Similarly, while spectrum has been made technology neutral, the associated spectrum usage charges, block sizes for trading, guard bands and roll-out obligations continue to vary across different technologies and bands. Thus, while India's adoption of the market regime is apparent, the level of market orientation is still a matter of concern and requires much regulatory streamlining.

To further analyse the transition of India's evolving mixed regime from 1999 to 2016, we first use Freyens (2009) framework, which was introduced previously, as a theoretical lens (Table 1).

As can be seen in Table 1, the framework helps to understand how various dimensions have evolved with time. India migrated from an inflexible to a flexible regime that was technology neutral and service neutral. India has also adopted auctions in the primary market and trading in the secondary market.

However, the framework loses out on complexities emerging from other aspects of the spectrum lifecycle not covered by the framework such as rollout obligations and usage charges associated with spectrum. This is partly due to the limited number of dimensions captured in the framework. The framework is also unable to reflect the situation in the time period between 2010 and 2015 wherein auctions existed in the primary market without trading in the secondary market. Similarly, the framework does not recognise that rights assignment from 1994 to 2009 went back and forth between auctions and administrative allocations including beauty contests, first-come-first-serve, and subscriber linked criteria. This is due to the limited set of values that each of the dimensions may

Table 1
Analysis of Indian Regime from Freyens (2009) Framework.

Module	India (1994–2009)	India (2010–2015)	India (2016)
Technical Flexibility (Yes/No)	No	No	Yes
Usage Flexibility (Rigid/Flexible)	Rigid	Semi-Rigid; Semi-Flexible	Flexible
Rights exclusivity (Full property rights, eased property rights, collective you)	Full property rights (exclusive, limited period license)	Full property rights (exclusive, limited period license)	Full property rights (exclusive, limited period license)
Rights assignment (administrative, auctioned and tradable, unlicensed)	Some Administrative; Some Auctioned (but not Tradable)	Auctioned (but not Tradable)	Auctioned and Tradable
Clubs membership (yes/no)	Not applicable	Not applicable	Not applicable
Rules control (self control, government managed)	Government managed	Government managed	Government managed

take. While the framework provides a general idea of how the Indian regime has evolved over time, it clearly emerges that it lacks dimensions and values within those dimensions that have the potential to explain the complexities of the Indian regime.

There are two reasons for the limited insights driven from Freyens (2009) framework. The first is Freyens (2009) lack of focus on the entire lifecycle of service provision. The second reason is that this framework was not embedded and developed in the Indian policy context and thus lacks the insights that the Indian regime has to offer. As highlighted above, the evolution of the Indian spectrum regime has often been a function of its weak institutions and the poor planning that comes with it. As a result, each policy initiative is embedded in complex legacy issues and difficult to undo after implementation (Jain, 2014).

7. Developing a framework for spectrum management in India

In this section, we propose a new framework that may be used as a theoretical basis to analyse India's changing regime in more depth. As explained previously, the framework was developed through an iterative coding process to ensure that all important dimensions of the Indian spectrum management regime are captured in the framework.

Taking the Freyen's (2009) framework forward, in our proposed framework, we incorporate the spectrum life cycle approach (Jain, 2010) that recognizes the following three stages (i) pre-service; (ii) service provision; and (iii) post-service. By superimposing it with the life cycle, the framework may be used as a diagnostic toolkit to examine the phases where there should be greater focus of regulation for an effective transition. The proposed framework has 10 dimensions. Each dimension introduces a comparable aspect of administrative and market regimes. By delineating various comparable aspects, it is possible to use it as a lens to specifically categorise a particular aspect of a given regime as administrative or market. The identified dimensions comprehensively cover all aspects of spectrum life cycle approach. Specifically, we identify the following dimensions of spectrum management:

i) spectrum assignment, ii) reorganisation of spectrum, iii) defined use, iv) ownership, v) obligations, vi) competition, vii) monitoring, viii) fee/charges, ix) tariff/pricing, x) exit/renewal.

The dimensions related to spectrum assignment, ownership, and competition refer to the pre-service provision stage. Likewise, dimensions related to reorganisation, obligations, defined use, tariff/pricing and fee/charges refer to the service provision stage. Finally, the dimension related to exit/renewals refers to the post-service provision stage (see Fig. 1).

For each of the dimensions, we identify the instruments used during the transition from a command and control/administrative to a market regime in Table 2. The instruments indicate the dimensions for a planning framework.

To further refine our framework, we identify the key elements that constitute each of the dimensions developed above. Each element reflects an important policy decision or an implementation practice for that dimension. To further assess the level of market orientation, we create two sub-categories: High and Low Level of Market Orientation. The choice of whether an element is categorized as having a High or Low Level of Market Orientation is based on the literature and a broad assignment to categories vis-à-vis our case study. There are some elements that may not have a clear categorization. But since this framework gives a direction for assessment, a lack of consensus on categorization of some elements does not reduce its effectiveness for an overall assessment. Further, while we propose High and Low Level of Market Orientation as a dichotomy capturing the two extreme ends of market orientation, future research may explore more categories. We also do not give relative weightage to any of the dimensions as each dimension reflects a qualitatively different aspect of spectrum management.

Even a broad categorization of existing prevailing practices in a policy regime will help us to assess its relative orientation as administrative or market. By carrying out this exercise for all elements and dimensions, we can get a comprehensive assessment of practices of the selected policy regime.

For example, in Table 3, for the dimension of 'Assignment', level of market orientation is assessed using the following three elements: i) 'Types of spectrum covered by auctions' ii) 'Quantity of spectrum put to auction', iii) 'Characteristics of auction design'. For the first element, we classify the practice where only the access spectrum is auctioned as having a low level of market orientation. The practice of having auctions for both access and backhaul demonstrates a high level of market orientation. Similarly, the level of market orientation is low when the government takes no proactive steps to make more spectrum available for commercial use. It will be considered high when spectrum is made available from a variety of sources in a time bound manner. For the element Auction Design, we may consider a low market orientation when there is a high reserve price, non-contiguous spectrum blocks and small spectrum block sizes. We may consider it high when there are appropriate levels of reserve price and block size and contiguous spectrum is made available.

This framework could be used by policy regimes to not just transition from administrative to market regimes, but also for identifying policy decisions and implementation practices that constitute higher levels of market orientation. While it is not feasible to claim that higher levels of market orientation are appropriate for all economies, the framework is aimed as a repository of policy options that regulators may consider before taking a decision.

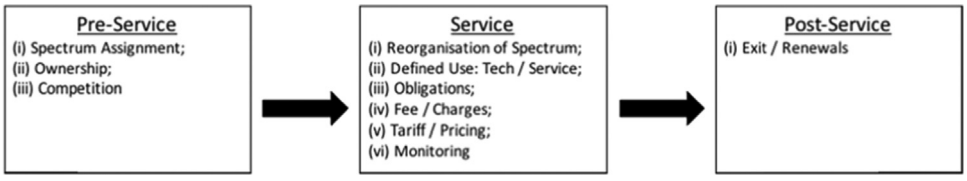

Fig. 1. Mapping Dimensions to Service Provision Lifecycle.

Table 2
Planning Framework for Transition to Market Regimes.

Dimension	Command and Control / Administrative	Market Based / Private Property	India (1999)	India (2012)	India (2016)
Spectrum Assignment	First Come First Serve, Beauty Contests, Lottery	Auctions	**Mix** of auctions and administrative assignments for access spectrum **Administrative**: Need basis assignments for backhaul spectrum	**Market**: Only auctions for licensed access spectrum **Administrative**: Need basis assignments for backhaul spectrum	**Market**: Only auctions for licensed access spectrum **Administrative**: Need basis assignments for backhaul spectrum
Re-Organisation of Spectrum	• Assignment of additional spectrum on need basis • Revocation of underutilised spectrum • Realignment of non-contiguous spectrum	Secondary Markets - Trading, Sharing, Leasing, Mergers, Acquisitions	**Administrative**: Subscriber Linked Criteria (SLC) for additional spectrum; No Trading	**None**: Neither SLC nor Trading allowed; Additional spectrum purchased only through auctions in primary market	**Market**: Spectrum Trading **Administrative**: Harmonisation of non-contiguous Spectrum
Defined Use: Technology / Service	• Defined technology/service for each band; • Administrative migration to new technology/service by refarming • Separate license for each service/ technology;	• Technology Neutrality • Service Neutrality	**Administrative**: Technology linked to each band eg GSM (900 & 1800 MHz); CDMA (800 MHz) **Administrative**: Separate license for each service	**Administrative**: Technology linked to each band eg GSM (900 & 1800 MHz); CDMA (800 MHz) **Mix**: Unified license for access licenses; separate license for other services	**Market**: Spectrum Liberalisation **Market**: Unified license for all services
Ownership	License to use for a limited time period subject to technical conditions (may be shared or exclusive)	Property rights – Perpetual, Exclusive right in terms of frequency, geography, time and use.	**Administrative**: 20 years exclusive license	**Administrative**: 20 years exclusive license	**Administrative**: 20 years exclusive license
Obligations	Spectrum linked to roll-out obligations for urban, rural and remote areas; Universal Service contributions	No obligations (Intervention in case of market failures)	**Administrative**: Rollout obligations and universal service obligations	**Administrative**: Rollout obligations and universal service obligations	**Administrative**: Rollout obligations and universal service obligations
Competition	Number of operators capped; Entry into telecom market controlled.	No regulatory cap on number of operators; Low entry barriers.	**Administrative**: Fixed number of competitors;	**Market**: No restrictions on competitors;	**Market**: No restrictions on competitors;
Monitoring	Reporting requirement of subscribers, utilisation; Testing and certification; Testing equipment mandated	Self-reporting / Certification / Random Checks	**Mixed**: Varying reporting requirements	**Mixed**: Varying reporting requirements	**Mixed**: Varying reporting requirements
Fee / Charges	Administratively determined charges. Eg. One-time fee and annual recurring charges that escalate charges with quantity of spectrum	Market determined auction prices; zero recurring charges.	**Administrative**: Escalating spectrum charges	**Administrative**: Escalating; new bands uniform	**Administrative**: Escalating; new bands uniform
Tariff / Pricing	Tariff approvals; Standard tariffs; Tariff ceilings	Forbearance	**Administrative:** Standard Tariff Packages	**Market:** Forbearance except tariff ceilings for rural subscribers	**Market:** Forbearance except tariff ceilings for national roaming and rural subscribers
Exit / Renewal	High obligations to exit market; Renewal or extension of license administratively guaranteed.	Low barriers to exiting market; Renewal or extension not assured in case of licenses.	**Administrative:** No exit route; extension of license for 10 years.	**Administrative:** No exit route; Policy for no administrative renewals or extensions.	**Market:** Exit policy announced; Policy for no administrative renewals or extensions.

Table 3
Implementation Framework for Level of Market Orientation.

Dimension	Elements	Administrative Regime	Market Regime		Indian Regime	
			Low Level of Market Orientation	High Level of Market Orientation	2012	2016
Spectrum Assignment	Types of spectrum covered by auctions	None	Only access spectrum	Access, backhaul, and other non-telecom spectrum	Low	Low
	Quantity of spectrum put to auction (supply, availability)	N/a	Low quantity; Artificial scarcity	All available spectrum put to auction; captive spectrum refarmed to increase availability	Low	High
	Auction Design					
	a) Reserve prices	N/a	High/Low reserve prices	Rational reserve prices	Low	Low
	b) Contiguity of spectrum	N/a	Non-contiguous fragmented spectrum	Contiguous spectrum	Low	High
	c) Block Size	N/a	Extremely small block sizes	Rational sizes (~5 MHz for LTE/UMTS)	Low	High
Re-Organisation of Spectrum	Types of spectrum allowed to be traded	None	Only spectrum purchased in auctions is tradable; Previously administratively purchased spectrum allowed if windfalls gains fee has been paid	All spectrum tradable	Admin	Low
	Characteristics of Trading Regime					
	a) Quantity of spectrum allowed to be traded	N/a	Only full spectrum or in stipulated block sizes that vary with technology and band	Any quantity including partial spectrum	Admin	Low
	b) Actors permitted to trade	N/a	Only telecom licensees	All including speculators	Admin	Low
	c) Transfer of linked rollout obligations	N/a	Rollout obligations retained by seller or doubly attributed to both seller and buyer in case of trading of partial spectrum;	Rollout obligations transferred in proportion to spectrum traded; rollout obligations also tradable	Admin	Low
	d) Transaction costs of a trade	N/a	High	Low/Zero	Admin	High
Defined Use: Technology / Service	Scope of technology flexibility	Only mandated technology	Choice between approved technologies for a band	Any technology in any band	Admin	High/ Medium
	Characteristics of Technology Neutral Regime					
	a) Interference management	N/a	Guard bands; Stipulated Power	Private Dispute / Mutual Decision	Admin	Low
	b) Types of spectrum liberalised	N/a	Only auctioned spectrum is liberalised; Previously administratively purchased spectrum allowed if windfalls gains fee has been paid	All assigned spectrum is liberalised	Admin	Low
	Integration of spectrum with service license	Single integrated license for service and spectrum	Single integrated license for service and spectrum	Separate licenses for spectrum and service	High	High
	Scope of service Flexibility	Different Licenses for All Services	Unified License for Access Services / Restrictions on type of service for a band (Voice/Data)	Unified License for all Services	Low	High
Ownership	Instrument for assigning rights	License	License	Register of ownership	Low	Low
	Time Period of rights	Revocable at discretion	Short (~10/20 years)	Perpetual	Low	Low
	Exclusivity of rights	Shared (usually exclusive)	Semi-exclusive (usually exclusive)	Exclusive	High	High
Obligations	Type of obligations	Rollout, Universal Service	Rollout, Universal Service	None	Low	Low
	Target beneficiary of obligations	Rural, Remote, Poor, Education	Rural, Remote, Poor, Education	None	Low	Low

(continued on next page)

Table 3 *(continued)*

Dimension	Elements	Administrative Regime	Market Regime		Indian Regime	
			Low Level of Market Orientation	High Level of Market Orientation	2012	2016
	Uniformity of obligations	Obligations vary with technology and band	Obligations vary with technology and band	Obligations do not vary with technology and band	Low	Low
	Services as part of obligations	Service Specific	Service Specific (Voice only)	Service Neutral (Voice and Data)	High	High
	Financial contributions towards meeting obligations	Fixed	Fixed	Incentive driven / Matched to expenditure	Low	Low
Competition	Entry in sector	Decided by government	Number of operators capped	No restrictions on entry	High	High
	Hoarding (Caps for maximum spectrum)	Need basis assignments	Band specific caps; Overall caps	No caps	Low	Low
Monitoring	Technology Compliance	Mandatory checks by Licensor;	Mandatory checks by Licensor; Random checks	Self-certification	Low	Low
	Quality of Service (QoS)	Defined QoS parameters	Defined QoS parameters	Market determined	Low	Low
Fees /Charges	Frequency of payment	Recurring/Annual	One time and Recurring/Annual	Onetime	Low	Low
	Calculation of fees	Slab based/Escalating with quantity	Slab based/Escalating with quantity	Flat	Low	Low
	Factors for calculation of fees	Varying for technology/licenses	Varying for technology/licenses	Uniform for all	Low	Low
Tariff / Pricing	Instrument for tariff regulation	Standard Tariff Packages	Tariff Ceilings	Complete Forbearance	Low	Low
	Class of Subscribers benefiting from tariff regulation	All	Rural/Remote/Poor	None	Low	Low
Exit / Renewal	Renewal or extensions	Administratively guaranteed/ assured extensions	Need to win back spectrum in auctions to renew services	Perpetual ownership. No need for renewals	Admin	Low
	Exit from sector	Strict exit policy	Strict exit policy	Flexible exit policy	Low	High

Taking the case of India, we see that India adopted auction as the instrument for assignment from 2012, although it limited auction only to access spectrum. This shows a low level of market orientation. For the 'Quantity of spectrum put to auction', there have been ad-hoc and ineffective mechanisms for making more spectrum available. Further there has been no time bound plan for the same. Thus, India has a low market orientation on this element. For assessing 'Characteristics of auction design', we find that although India has transitioned from using simple designs to sophisticated ones, its outcomes have not been effective in terms of its ability to sell all the spectrum put out for bids. This has been due to high reserve prices, non-contiguous and small blocks. So, while India has transitioned to a market regime, it has a relatively lower level of market orientation for assignment of spectrum.

To improve its market orientation, India would have to consider auction for backhaul, make efforts to coordinate with various agencies such as Defence, Police and Home departments to make more spectrum available and adopt better auction design practices. Thus, we see that the above framework could be used for assessment and planning for transition.

From Table 3 we see that India had transitioned to a Market Orientation by 2016 from a largely Administrative Orientation in 1999. The last column in Table 3 indicates that despite the Market Orientation, India's rating on all the dimensions across the spectrum life cycle was Low.

From the case study, it is clear that having a market regime with high level of market orientation in only some aspects of the service provision cycle may not lead to expected policy outcomes such as increasing the growth of wireless or competition. Spectrum management regimes need to keep in mind that operators consider policy dimensions in the entire life cycle for assessing the viability of service provision. Further, when changes in orientation are implemented in only a few dimensions, these may lead to complex legacy issues subsequently. For example, while DoT implemented auctions in the 2300 MHz band, it initially restricted use of this band to data services only. Given that voice services were the mainstay of most operators in India, this band was not considered very favourably by operators. Likewise, regulators in many countries have imposed more stringent roll-out obligations in the 700 MHz and 800 MHz bands in comparison to other bands as these have better propagation characteristics (Cramton &

Table 4
Legacy Issues in Migration from Command and Control to Market Regime.

Dimension	Legacy Issues in Migration from Command and Control to Market Regime
Spectrum Assignment	• Determining reserve prices in absence of any previous market valuations. • Possible surge in tariffs due to high market valuations of spectrum • Previous legal obligations to existing licensees for administrative allocation. • Increased regulatory complexity due to simultaneous existence of administrative and market licensees.
Re-Organisation	• Windfall gains through secondary market trading for licensees who received initial allocation at administratively determined low costs; • Determining fee/tax to prevent windfall gains; • Windfall gains tax create disincentive for incumbents with established businesses. • Initial fragmented/non-contiguous administrative allocations create high transaction costs. • Transfer of rollout obligations in case of partial transfer of spectrum
Defined Use: Technology / Service	• Liberalising spectrum (making it technology neutral) in the hands of incumbents holding efficient/premium spectrum (eg. 900 MHz) can create level playing field issues. • Determining fee for liberalising spectrum held by licensees who received spectrum administratively at low prices. • Managing interference between operators previously dependent on regulator to create band gaps
Ownership	• Spectrum needs to be delinked from licenses to allow trading of spectrum in secondary markets. • Legal opposition to mandatory migration to new licensing regime • Mix of new and old licenses further increases complexity of licensing regime.
Obligations	• Operators resist contributions to Universal Service after paying market prices for spectrum. • Operators challenge increase in obligations after paying market prices.
Competition	• May lead to sudden unforeseen consolidation due to operators seeking to exit. • May lead to high spectrum valuations due to opening of sector to competition. • Technology/band specific caps to prevent hoarding. Non-substitutability of band characteristics of different bands/
Monitoring	• Regulators continue to mandate Quality of Services parameters and permissible technologies • Quality of information/reports reduces.
Charges/Fees	• Create level playing field issues if spectrum usage charges are reduced for incumbents that hold high quantity of administratively allocated spectrum. • Mix of escalating and flat charges for administrative and market licensees complicates financial regime.
Tariffs/Pricing	• Operators argue that tariffs should be unregulated if prices of spectrum are determined by the market possibly leading to a surge in tariffs.
Exit/Renewal	• Extension of licenses on expiry that were previously administratively allocated. • Previous valuations did not account for uncertainty in winning back spectrum. • Burden on operators to win back spectrum to protect investments

Ockenfels, 2014). This violated band and technology neutrality.

Table 4 sets out various legacy issues faced by India in transitioning from an administrative to a market regime for each of the 10 dimensions. While the identified issues are a function of the legacy administrative framework and would not be exactly the same for any other country, the issues are presented in a way such that they may be used as learnings for other countries that seek to transition to more market oriented regimes in the future. Many of these legacy issues are already identified in literature (Cave & Webb, 2015), however we present them as part of a structured framework that may be applied by the regulator in a comprehensive manner covering all aspects of the spectrum provision lifecycle.

8. Contributions

This paper contributes to the study of spectrum policy regimes and fills an important gap by providing a perspective from India, an emerging economy characterized by weak institutional structures (Horowitz, 1989; Liu & Jayakar, 2012). Further we developed a framework that may be used as a theoretical lens for examining spectrum policy regime in terms of their market orientation. This work extends prior theoretical contributions (Freyens, 2009; Minervini, 2014) by providing a structure through the spectrum life cycle approach for identifying the relevant dimensions. Firstly, by adopting a life cycle approach, we ensure comprehensive coverage of various dimensions of spectrum policy regimes. This approach helped to add additional dimensions across which regimes may be compared. Secondly, the framework breaks-up the dimensions into their constituent elements and thus provides a more nuanced approach to the analysis of spectrum policy regimes. These contributions were possible because the proposed framework is constructed in the Indian policy context that has seen a substantial change in its spectrum policy regime.

The insights drawn from the Indian case study are a reflection of the nature of institutional arrangements in India and the legacy issues that it faces. These insights also help to deal with the complexity ingrained in emerging economy contexts.

Further, by refining the dimensions of the framework in terms of the constituent elements and associating degrees of market orientation with each element, we extended existing theory. This also provides a practical mechanism to assess the overall market orientation of any spectrum policy regime. Subsequently, by identifying the challenges faced by India in each dimension during the transition, we developed a roadmap for implementation for adopting a higher market orientation. This would provide useful insights for regulators in other developing countries.

9. Conclusions

Growth in wireless services as the underlying driver for future economic growth has led policy makers and regulators to examine the policy regimes under which spectrum is managed. With developments in technology and changes in regulation, policy makers in several countries are moving from a predominantly administrative regime to more market oriented ones. Market oriented regimes facilitate competition, innovation and growth in services. Regulatory regimes can facilitate this through technology and service flexibility to operators while ensuring concerns related to universal provision.

By building on prior theoretical frameworks and extending the same to provide a comprehensive coverage across the service provision life cycle in the context of India, we also identified a mechanism to assess the overall market orientation of a policy regime. We used the framework in the Indian context to show that while India had adopted market mechanisms, it had a low level of market orientation. While this framework was developed in the Indian context, it may also be used as an assessment tool for evaluating the relative market orientation of different spectrum policy regimes in other jurisdictions.

Further, by examining the constituent elements of the dimensions in the proposed framework, and identifying the challenges in the transition at the constituent element level, we provided an implementation roadmap for countries proposing to move towards a more market oriented regime. We highlighted the legacy issues that may be faced as a result of migration for each of the dimensions. These are documented as learnings for other countries that may follow the same path.

Amongst other insights, it was seen that transitioning to a market regime via micromanaging and incremental changes may create additional legacy issues and substantially increase the complexity of the regulatory regime, thereby further slowing the transition.

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