Spillover Effects in Complementary Markets: A Study of the Indian Cellphone and Wireless Service Markets

Chirantan Chatterjee
Univ. of Sussex

Ying Fan
Univ. of Michigan
CEPR, NBER

Debi P. Mohapatra
Univ. of Massachusetts

August 6, 2024

This Paper

- Studies the indirect network effects on product variety and firm entry in two complementary markets
  - Indirect network effects occur when the value of a product in one market depends on products in another market
  - Examples: EV-charging station, hardware-software, cellphone-wireless plans, ...
  - They affect demand, firm pricing, and ...

- Highlights and quantifies a new channel: Presence of technologically more advanced int'l firms in an open market
  - Contributes to the development of a complementary market by encouraging entry (firm entry)
  - Affects domestic firms in the open market by affecting their profits from new products (product variety)

This Paper

- Studies the indirect network effects on product variety and firm entry in two complementary markets
  - Indirect network effects occur when the value of a product in one market depends on products in another market
  - Examples: EV-charging station, hardware-software, cellphone-wireless plans, ...
  - They affect demand, firm pricing, and ...

- Highlights and quantifies a new channel: Presence of technologically more advanced int'l firms in an open market
  - Contributes to the development of a complementary market by encouraging entry (firm entry)
  - Affects domestic firms in the open market by affecting their profits from new products (product variety)

Setting

Indian mobile industry during the 4G rollout

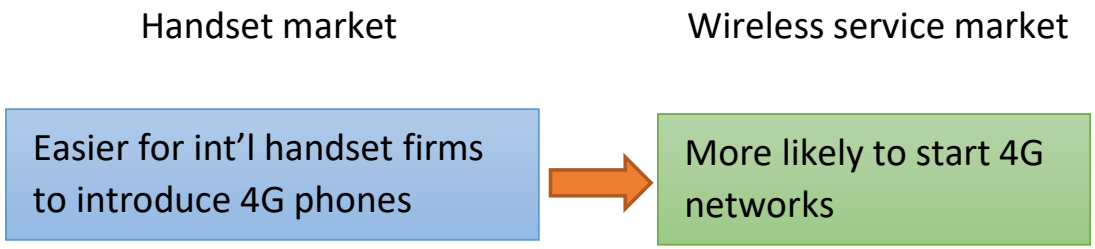
- Two markets
  - **handset market**: int'l handset firms play an important role and occupy the higher-end of the market
  - **wireless service market**: mostly Indian carriers
- Two complementary markets
  - a consumer needs both a handset and a service plan to enjoy mobile service
  - only enjoys advanced features and the fast speed with a 4G handset/4G network combination

Setting

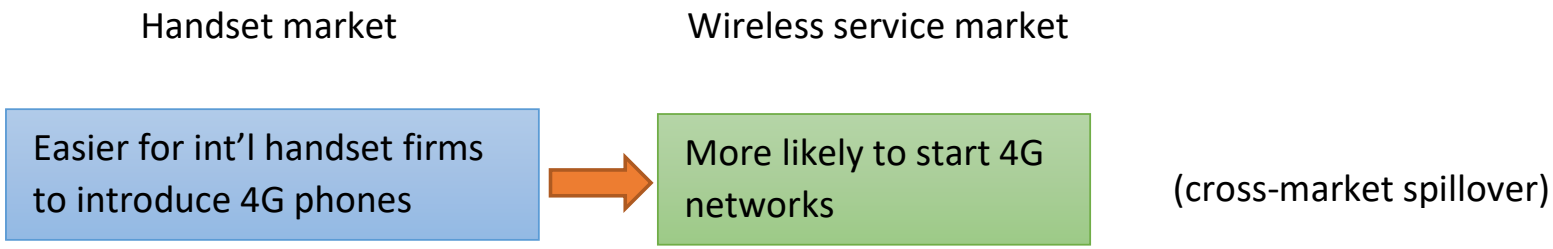
Indian mobile industry during the 4G rollout

- Two markets
  - **handset market**: int'l handset firms play an important role and occupy the higher-end of the market
  - **wireless service market**: mostly Indian carriers
- Two complementary markets
  - a consumer needs both a handset and a service plan to enjoy mobile service
  - only enjoys advanced features and the fast speed with a 4G handset/4G network combination

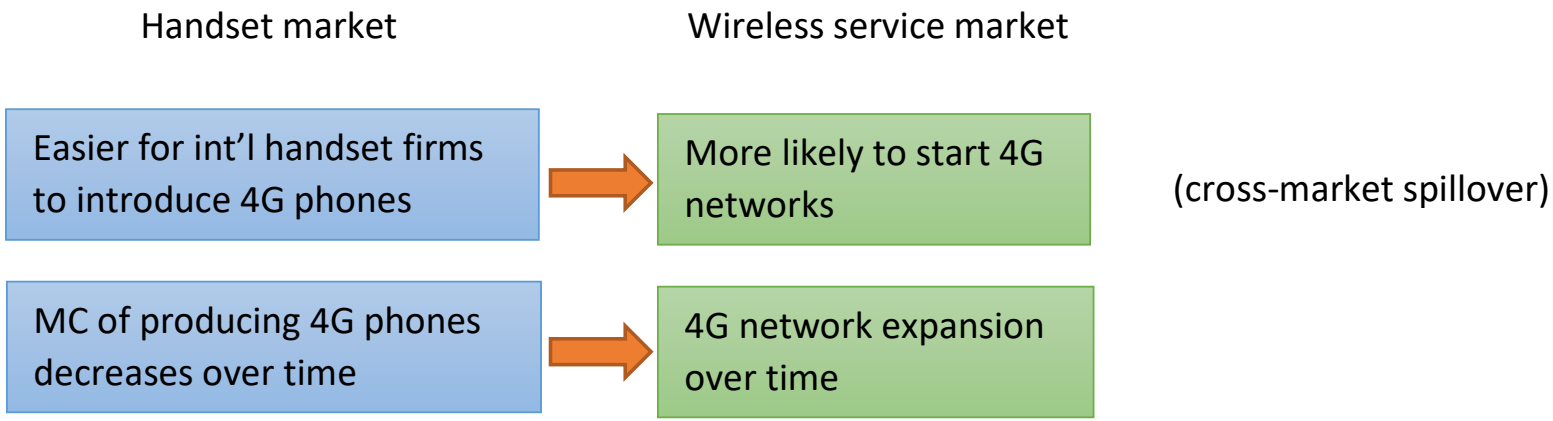
The Channel


Handset market
Wireless service market
Easier for int'l handset firms to introduce 4G phones
More likely to start 4G networks

The Channel


Handset market
Wireless service market
Easier for int'l handset firms to introduce 4G phones
More likely to start 4G networks
(cross-market spillover)

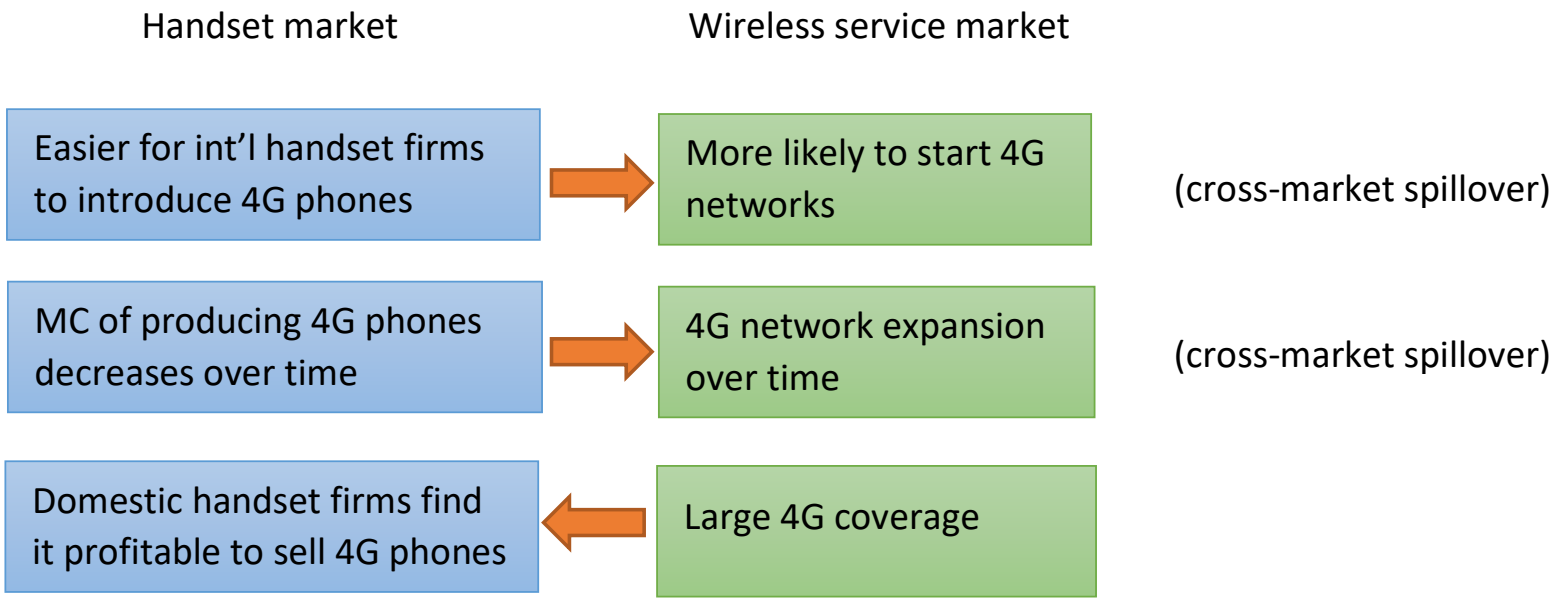
The Channel


Handset market
Wireless service market
Easier for int'l handset firms to introduce 4G phones
More likely to start 4G networks
MC of producing 4G phones decreases over time
4G network expansion over time
(cross-market spillover)

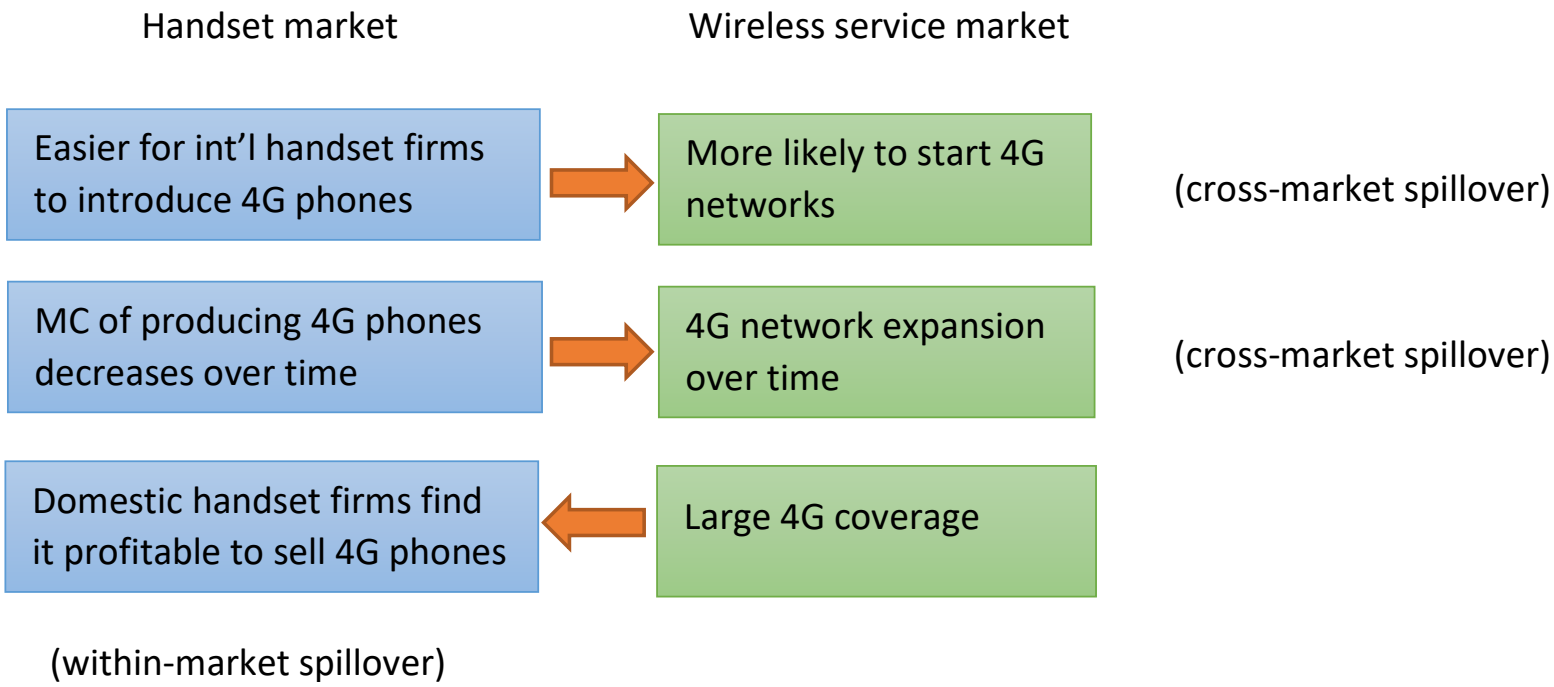
The Channel

Handset market		Wireless service market	
Easier for int'l handset firms to introduce 4G phones	→	More likely to start 4G networks	(cross-market spillover)
MC of producing 4G phones decreases over time	→	4G network expansion over time	(cross-market spillover)

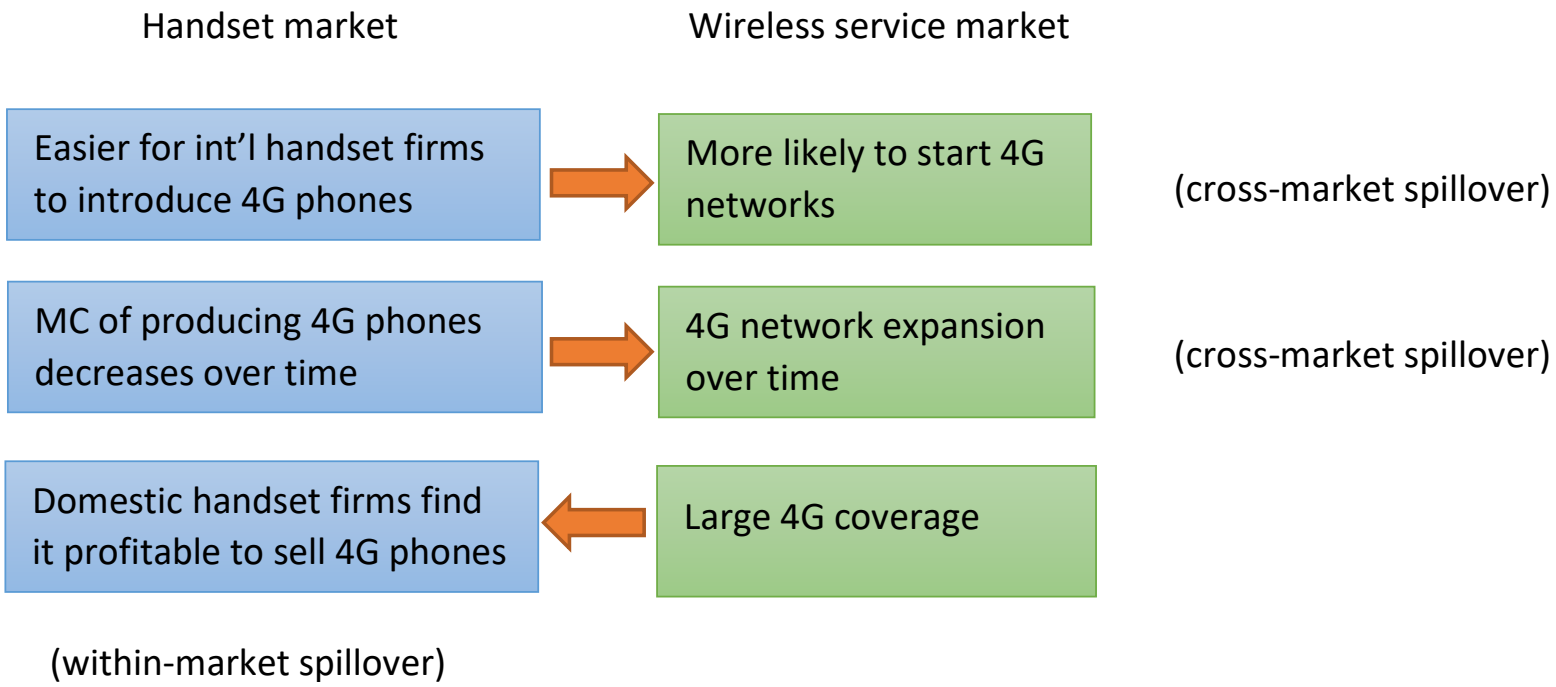
The Channel


Handset market
Wireless service market
Easier for int'l handset firms to introduce 4G phones
More likely to start 4G networks
(cross-market spillover)
MC of producing 4G phones decreases over time
4G network expansion over time
(cross-market spillover)
Domestic handset firms find it profitable to sell 4G phones
Large 4G coverage

The Channel


Handset market
Wireless service market
Easier for int'l handset firms to introduce 4G phones
More likely to start 4G networks
(cross-market spillover)
MC of producing 4G phones decreases over time
4G network expansion over time
(cross-market spillover)
Domestic handset firms find it profitable to sell 4G phones
Large 4G coverage
(within-market spillover)

The Channel



- The presence of the technologically more advanced int'l handset firms speeds up the expansion of 4G network and may accelerate the introduction of 4G handsets by domestic firms, benefiting consumers

Research Questions

1. How does the presence of int'l handset firms affect the rollout of 4G networks?
   - cross-market effect
2. How does the presence of int'l handset firms affect the introduction of 4G handsets by Indian handset firms?
   - within-market effect
3. What is the welfare effect?
   - margins: 4G networks, product variety, and prices

What We Do

- Develop a structural model of demand, network expansion, product choice, and pricing in the Indian handset and wireless service markets
- Estimate the model using data on handsets, plans, and networks
  - four key empirical findings
- Quantify the spillover effects and the welfare effects
  - three counterfactual simulations

Literature Review and Contributions - A Short Version

1. We study two complementary markets simultaneously
   - Literature on network effects b/w complementary markets
   - This paper: a new topic
2. We study both handset firms' product choices and carriers' network expansion decisions
   - Literature on endogenous product choice
   - Literature on dynamic entry games
   - This paper: both - embed a static product choice model in a dynamic network expansion model
3. We study the effect of opening a market to international competitors
   - Trade literature
   - This paper: a new channel

Industry Background

- Handset market: 4 Indian, 6 other-Asian, and 2 non-Asian handset firms
- Wireless market: 8 carriers – Airtel, Vodafone, Idea, BSNL, Reliance Jio, Reliance Communications, Aircel, MTNL
- 22 telecommunications regions: 3 Metro regions (most developed: Delhi, Kolkata, Mumbai), 5 Category-A, 8 Category-B, and 6 Category-C regions (least developed) ▸ map

Data

- 2011 – 2018Q2
- Handset data
  - price, sales, and product characteristics at the product/time level
- Wireless service data
  - price and sales at the plan/quarter level
  - availability at the plan/quarter/region level ▸ video
  - plan = carrier/technology (e.g., Airtel 4G)
- ▸ summary stats

Data Pattern 1

1. Int'l firms, especially other Asian firms, play an important role in the handset market

Origin	Firm	Sales Share	Total
Indian	Intex	3.3%	
Indian	Lava	3.2%	
Indian	LYF	15.7%	
Indian	Micromax	6.0%	28%
Other-Asian	Gionee	1.3%	
Other-Asian	Lenovo	4.9%	
Other-Asian	Oppo	4.8%	
Other-Asian	Samsung	33.0%	
Other-Asian	Vivo	6.2%	
Other-Asian	Xiaomi	13.7%	64%
Non-Asian	Apple	1.8%	
Non-Asian	Microsoft/Nokia	6.1%	8%

- Sales share = (3G/4G handset sales by a firm in the sample)/(total 3G/4G handset sales)

Data Pattern 2

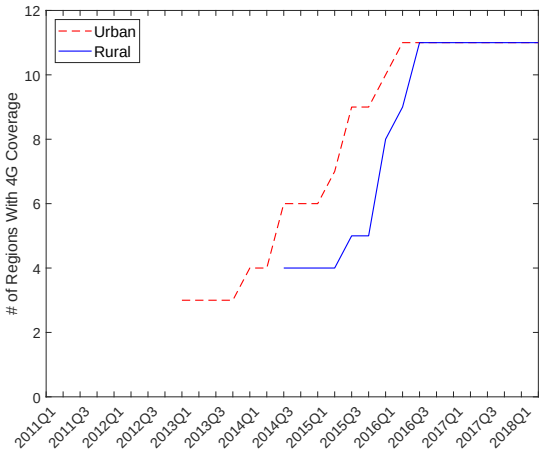
2. While Indian handset firms occupy the low-end market, int'l handset firms dominate the higher end of the market.

	4G Handset Sales Share		
Origin	Low-Price	Medium-Price	High-Price
Indian	100%	26%	1%
Other Asian	-	74%	91%
Non-Asian	-	-	7%

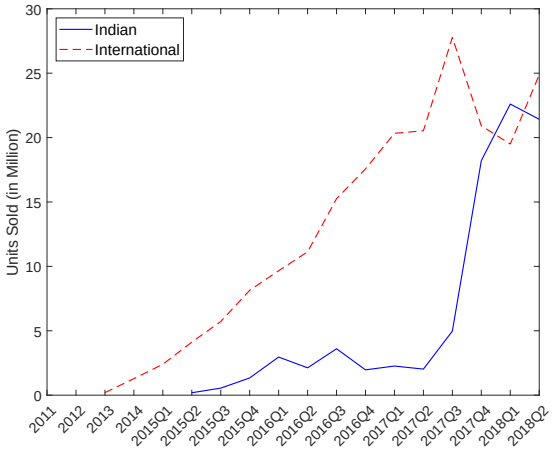
Data Pattern 3

3. Co-movement in the two markets: 4G network coverage expanded and 4G handset sales increased

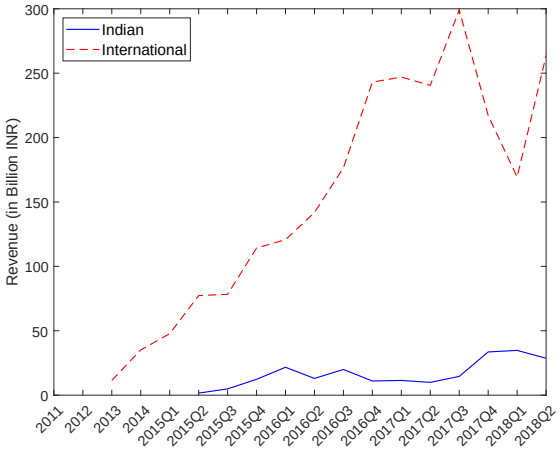
(a) # 4G Regions



(b) Sales of 4G Handsets



(c) Rev. of 4G Handsets



- Consistent with Pattern 2, the increase in Indian 4G handset sales is largely driven by a set of low-end phones

▸ JioPhone

Data Patterns: Summary

- Int'l handset firms play a big role in the handset market
- They started selling 4G handsets first and Indian firms later introduced low-end 4G handsets
- Concurrent 4G handset sales growth and 4G network expansions

Model Outline

Demand

$$s^h\left(\underbrace{p_t^h}_{\text{handset prices}}, \underbrace{p_t^p}_{\text{plan prices}}, \underbrace{\mathcal{J}_t^h}_{\text{available handsets}}, \underbrace{\{\mathcal{R}_{ct}\}_{c=1}^{C}}_{\text{each carrier's network}}\right), s^p(\dots)$$

Model Outline

Demand

$$s^h\left(\underbrace{p_t^h}_{\text{handset prices}}, \underbrace{p_t^p}_{\text{plan prices}}, \underbrace{\mathcal{J}_t^h}_{\text{available handsets}}, \underbrace{\{\mathcal{R}_{ct}\}_{c=1}^{C}}_{\text{each carrier's network}}\right), s^p(\dots)$$

Static product choice model

Dynamic carrier 4G network expansion game

Model Outline

Demand

$$s^h\Big(\underbrace{p_t^h}_{\text{handset prices}}, \underbrace{p_t^p}_{\text{plan prices}}, \underbrace{\mathcal{J}_t^h}_{\text{available handsets}}, \underbrace{\{\mathcal{R}_{ct}\}_{c=1}^C}_{\text{each carrier's network}}\Big), s^p(\dots)$$

Static product choice model

Stage-2 pricing eqm:
$p^{*h}\left(\mathcal{J}_t^h, \{\mathcal{R}_{ct}\}_{c=1}^C\right),\ p^{*p}(\dots)$

Stage-1 product choice eqm: $\mathcal{J}_t^{*h}(\{\mathcal{R}_{ct}\}_{c=1}^C)$

→ Eqm carrier profit given networks: $\pi_{ct}(\{\mathcal{R}_{ct}\}_{c=1}^C)$

Dynamic carrier 4G network expansion game

Model Outline

Demand

$$s^h\left(\underbrace{p_t^h}_{\text{handset prices}}, \underbrace{p_t^p}_{\text{plan prices}}, \underbrace{\mathcal{J}_t^h}_{\text{available handsets}}, \underbrace{\{\mathcal{R}_{ct}\}_{c=1}^C}_{\text{each carrier's network}}\right), s^p(\dots)$$

Static product choice model

Stage-2 pricing eqm:
$p^{*h}\left(\mathcal{J}_t^h, \{\mathcal{R}_{ct}\}_{c=1}^C\right),\ p^{*p}(\dots)$

Stage-1 product choice eqm: $\mathcal{J}_t^{*h}(\{\mathcal{R}_{ct}\}_{c=1}^C)$

→ Eqm carrier profit given networks: $\pi_{ct}(\{\mathcal{R}_{ct}\}_{c=1}^C)$

Dynamic carrier 4G network expansion game

Carrier 1 expansion decision a_{1t}

$(\mathcal{R}_{1t}, \dots, \mathcal{R}_{4t})$

- $a_{1t} = \emptyset$ → $(\mathcal{R}_{1t} \cup \emptyset, \mathcal{R}_{2t} \cup a_{2t}, \dots, \mathcal{R}_{4t} \cup a_{4t})$
- ⋮
- $a_{1t} = \mathcal{R}\backslash\mathcal{R}_{1t}$ → $(\mathcal{R}_{1t} \cup \mathcal{R}\backslash\mathcal{R}_{1t}, \mathcal{R}_{2t} \cup a_{2t}, \dots, \mathcal{R}_{4t} \cup a_{4t})$

$\pi_{1t}(\mathcal{R}_{1t}, \dots, \mathcal{R}_{4t})$ | $-f(a_{1t}) + \varepsilon(a_{1t})$ | $E_{(a_{2t}, a_{3t}, a_{4t})} V_{1t+1}(\mathcal{R}_{1t} \cup a_{1t}, \mathcal{R}_{2t} \cup a_{2t}, \dots, \mathcal{R}_{4t} \cup a_{4t})$

Model Outline

Demand

$$s^h\left(\underbrace{p_t^h}_{\text{handset prices}}, \underbrace{p_t^p}_{\text{plan prices}}, \underbrace{\mathcal{J}_t^h}_{\text{available handsets}}, \underbrace{\{\mathcal{R}_{ct}\}_{c=1}^C}_{\text{each carrier's network}}\right), s^p(\dots)$$

Static product choice model

Stage-2 pricing eqm:

$p^{*h}\left(\mathcal{J}_t^h, \{\mathcal{R}_{ct}\}_{c=1}^C\right),\ p^{*p}(\dots)$

Stage-1 product choice eqm: $\mathcal{J}_t^{*h}(\{\mathcal{R}_{ct}\}_{c=1}^C)$

→ Eqm carrier profit given networks: $\pi_{ct}(\{\mathcal{R}_{ct}\}_{c=1}^C)$

Dynamic carrier 4G network expansion game

Carrier 1 expansion decision a_{1t}

$(\mathcal{R}_{1t}, \dots, \mathcal{R}_{4t})$

- $a_{1t} = \emptyset$ → $(\mathcal{R}_{1t} \cup \emptyset, \mathcal{R}_{2t} \cup a_{2t}, \dots, \mathcal{R}_{4t} \cup a_{4t})$
- ⋮
- $a_{1t} = \mathcal{R} \backslash \mathcal{R}_{1t}$ → $(\mathcal{R}_{1t} \cup \mathcal{R} \backslash \mathcal{R}_{1t}, \mathcal{R}_{2t} \cup a_{2t}, \dots, \mathcal{R}_{4t} \cup a_{4t})$

$\pi_{1t}(\mathcal{R}_{1t}, \dots, \mathcal{R}_{4t})$ | $-f(a_{1t}) + \varepsilon(a_{1t})$ | $E_{(a_{2t}, a_{3t}, a_{4t})} V_{1t+1}(\mathcal{R}_{1t} \cup a_{1t}, \mathcal{R}_{2t} \cup a_{2t}, \dots, \mathcal{R}_{4t} \cup a_{4t})$

Estimation Results: Demand

	Est.	Std. Error
Price (10K INR)	-29.1***	5.57
Price × Income	4.47***	0.89
Price × Normal Draw	0.36***	0.15
Screen Size (Inch)	0.27*	0.17
Camera (MP)	0.09***	0.02
Storage (10GB)	0.41***	0.07
RAM (GB)	0.39***	0.15
Battery Capacity	0.32***	0.11
$\mathbb{1}$(4G Handset)× $\mathbb{1}$(4G Network)	3.24***	0.82
Handset Technology FE	Yes	
Plan Technology FE	Yes	
Handset Firm FE	Yes	
Carrier FE	Yes	
Time FE	Yes	
Jio First Year FE	Yes	

- The estimated coefficient of 3.24 is equivalent to a willingness to pay of 4,248 INR given the average price coefficient

Estimation Results: Demand

	Est.	Std. Error
Price (10K INR)	-29.1***	5.57
Price × Income	4.47***	0.89
Price × Normal Draw	0.36***	0.15
Screen Size (Inch)	0.27*	0.17
Camera (MP)	0.09***	0.02
Storage (10GB)	0.41***	0.07
RAM (GB)	0.39***	0.15
Battery Capacity	0.32***	0.11
$\mathbb{1}$(4G Handset)× $\mathbb{1}$(4G Network)	3.24***	0.82
Handset Technology FE	Yes	
Plan Technology FE	Yes	
Handset Firm FE	Yes	
Carrier FE	Yes	
Time FE	Yes	
Jio First Year FE	Yes	

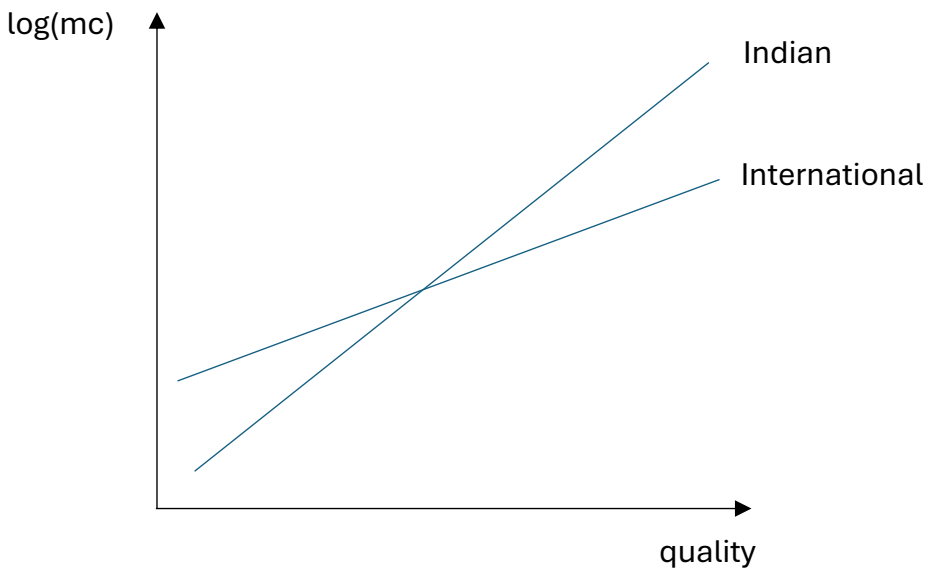
Complementarity b/w 4G handsets & 4G networks

- The estimated coefficient of 3.24 is equivalent to a willingness to pay of 4,248 INR given the average price coefficient

Estimation Results: Marginal Cost

Table: MC Estimation Result

1. Indian handset firms have a cost advantage at the low end



2. MC costs decrease over time: negative coefficients for time trend

Estimation Results: Fixed Cost

Finding: cost advantages of int'l handset firms:

Median 4G Handset Fixed Cost (Million INR)

Origin	Low-Quality	Low-Medium	High-Medium	High-Quality
Indian	983	1458	-	-
International	544	1353	5003	5984

▸ details

Estimation Results: Fixed Cost

Finding: cost advantages of int'l handset firms:

Median 4G Handset Fixed Cost (Million INR)

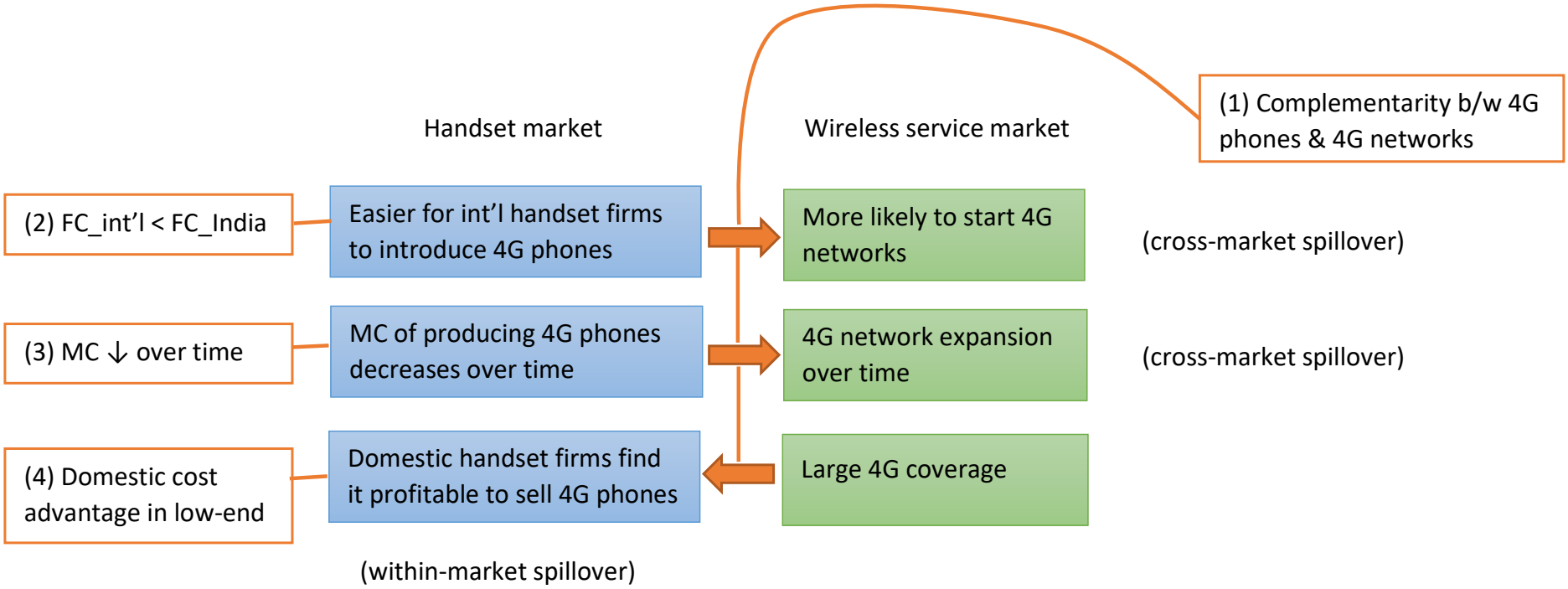
Origin	Low-Quality	Low-Medium	High-Medium	High-Quality
Indian	983	1458	-	-
International	544	1353	5003	5984

▸ details

Estimation Results: Summary

1. Complementarity between 4G phones and 4G networks
2. Lower fixed cost for int'l handset firms to sell 4G handsets
3. Declining marginal cost
4. Domestic cost advantage at producing low-quality handsets

Key Findings and the Channel



- Finding 1 is the foundation for the spillover effects
- Findings 2 and 3 support the cross-market spillover effect at the initial stage of the 4G rollout and in the later stage of the continued expansion
- Finding 4 gives rise to the within-market spillover effect so that Indian handset firms benefit from the presence of int'l handset firms

Counterfactual Simulation Design

- Quantification
  - CF1. remove int'l handset firms from India
  - CF2. replace each int'l handset firms by an Indian firm
- A policy analysis
  - CF3. ban on budget Chinese phones (price $<$ 12,000 INR)
- Fixed:
  - 2G and 3G networks
  - each handset firm's potential products
- Recomputed:
  - 4G network in each period
  - set of handsets in each period
  - handset prices and plan prices in each period

Counterfactual Simulation Design

- Quantification
  - CF1. remove int'l handset firms from India
  - CF2. replace each int'l handset firms by an Indian firm
- A policy analysis
  - CF3. ban on budget Chinese phones (price $<$ 12,000 INR)
- Fixed:
  - 2G and 3G networks
  - each handset firm's potential products
- Recomputed:
  - 4G network in each period
  - set of handsets in each period
  - handset prices and plan prices in each period

Counterfactual Simulation Design

- Quantification
  - CF1. remove int'l handset firms from India
  - CF2. replace each int'l handset firms by an Indian firm
- A policy analysis
  - CF3. ban on budget Chinese phones (price $<$ 12,000 INR)
- Fixed:
  - 2G and 3G networks
  - each handset firm's potential products
- Recomputed:
  - 4G network in each period
  - set of handsets in each period
  - handset prices and plan prices in each period

CF1. Economic Forces

CF1. Remove int'l handset firms from India

- Affects prices (less competition)
- Affects handset variety directly (products by int'l firms removed)
- Affects handset variety indirectly by affecting Indian handset firms' product choices
- Affects 4G networks, which, in turn, affects Indian handset firms' product choices and pricing competition

CF2 Details

CF2. Replace each int'l handset firms by an Indian firm

- Less of a shock to the industry
- Accommodates the possibility that the void created by the absence of the int'l firms may be filled by the entry of new domestic firms

Operationalization:

- Firm fixed effect in demand: $\text{FE}^{\text{CF}} = \text{avg}(\hat{\text{FE}}_{\text{Indian}})$
- MC: $\mathbb{1}(\text{Indian}) = 1$
- Fixed cost: $C_{jt}^{\text{CF}} = \frac{\text{avg}_{j \in \text{Indian}} \hat{C}_{jt}}{\text{avg}_{j \in \text{Int'l}} \hat{C}_{jt}} \hat{C}_{jt}$

CF3 Details

CF3. ban on budget Chinese phones

- Chinese handset firms face a price floor of 12,000 INR

- Affects prices
- Affects product choices
- Affects 4G networks, which, in turn, affects handset firms' product choices and pricing competition

Expected Results

1. Cross-market spillover effect
   - Outcome of interest: evolution of # regions and population covered by 4G networks
   - Expected result: a slower expansion of 4G networks in CF b/c
     - estimated cost advantage of int'l handset firms in selling 4G phones
     - estimated complementarity between 4G phones and 4G handsets

Expected Results (Cont.)

2. Within-market spillover effect

- Outcome of interest: evolution of # and sales of Indian 4G phones
- Expected result: ambiguous
  - slower expansion of 4G networks $\rightarrow$ a later intro and a slower growth of domestic 4G phones
  - less competition, higher variable profits $\rightarrow$ an earlier intro and a faster growth of domestic 4G phones

Expected Results (Cont.)

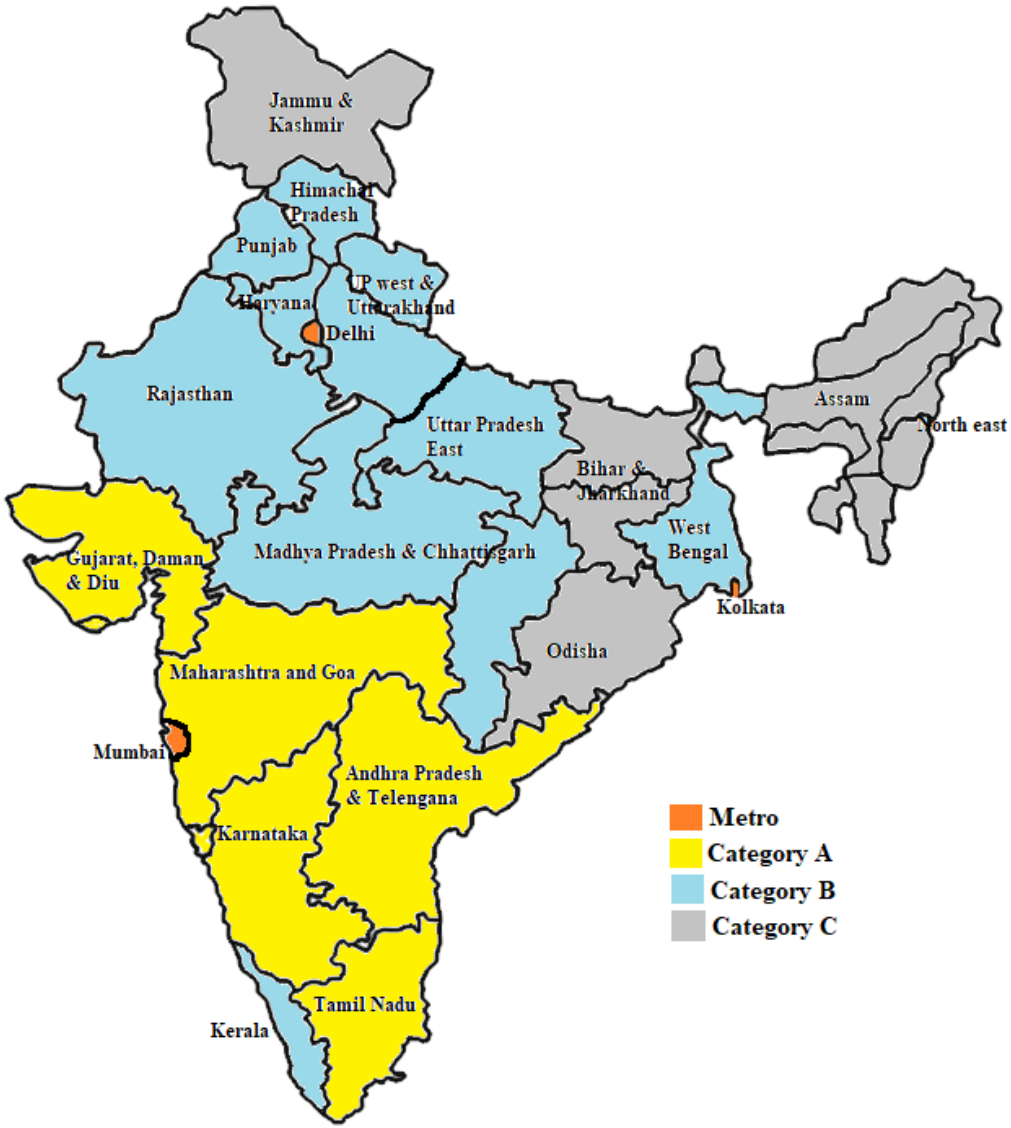
3. Welfare
   - Consumer surplus $\downarrow$ b/c
     - slower expansion of 4G network coverage
     - slower development of the 4G phone market
   - Carrier profits $\downarrow$ b/c
     - complementarity between the two markets
   - Domestic handset firms' profits ?
     - less competition in CF1 scenario, more homogeneous competitors in CF2, less competition in the low-end of the market in CF3
     - no within-market spillover effect

Conclusion

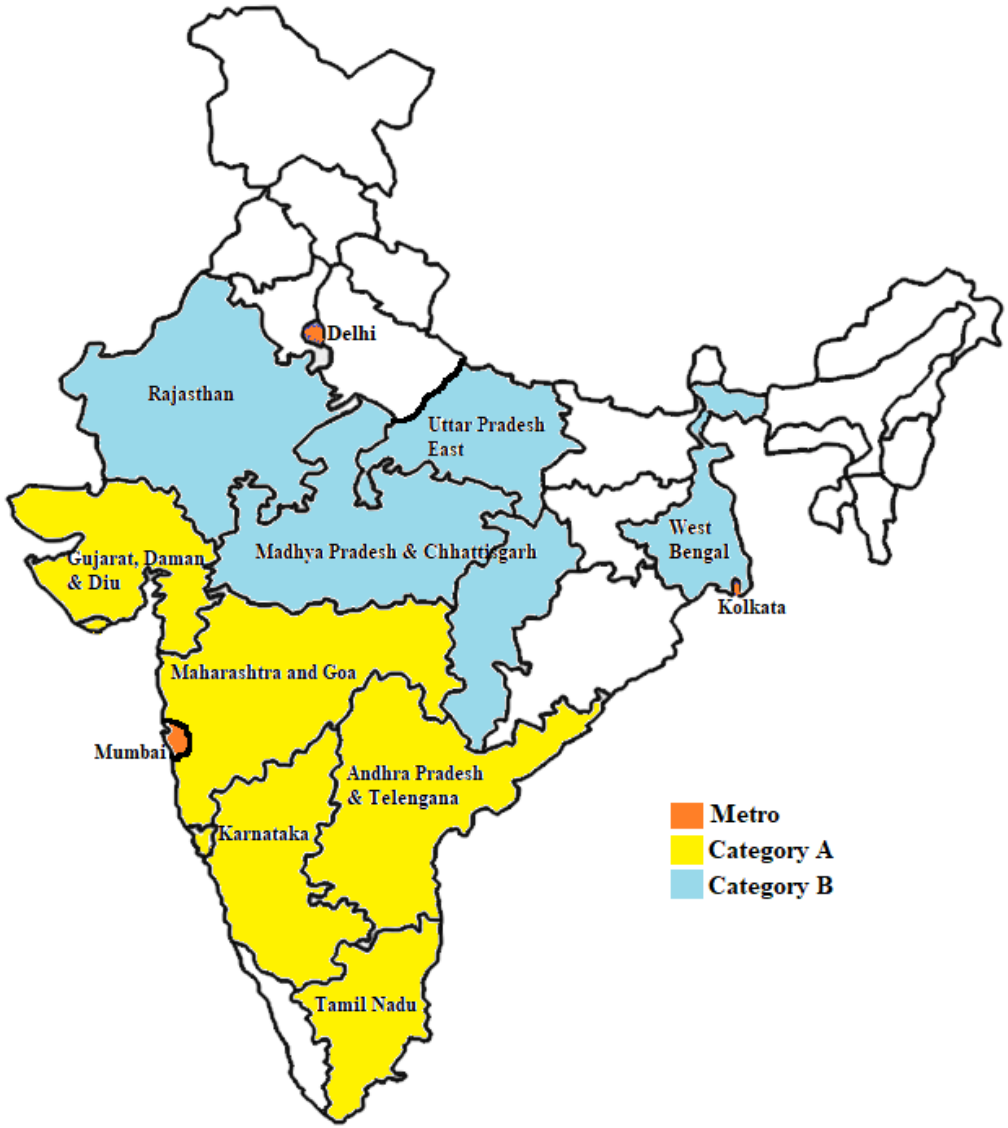
- Indirect network effects on product variety and firm entry
- A new channel through which int'l competition affects product variety and welfare
  - presence of int'l firms helps the development of a complementary market, which, in turn, affect their own market
- Four key findings supporting the channel
  - 4G-4G complementarity
  - int'l firm cost advantages
  - declining MC
  - domestic cost advantage at producing low-end handsets
- Quantify the cross-market and within-market spillover effects, and the welfare effects

Thank you!

Telecommunications Regions in India



The 12 Telecommunications Regions



JioPhone

JioPhone LF-2401

Screen Size	2.4 inch
Rear Camera	2MP
Front Camera	0.3MP
RAM	0.5GB
4G connectivity	Yes
Built-in Apps	Yes
Voice control	Yes
Price	$22 in 2017

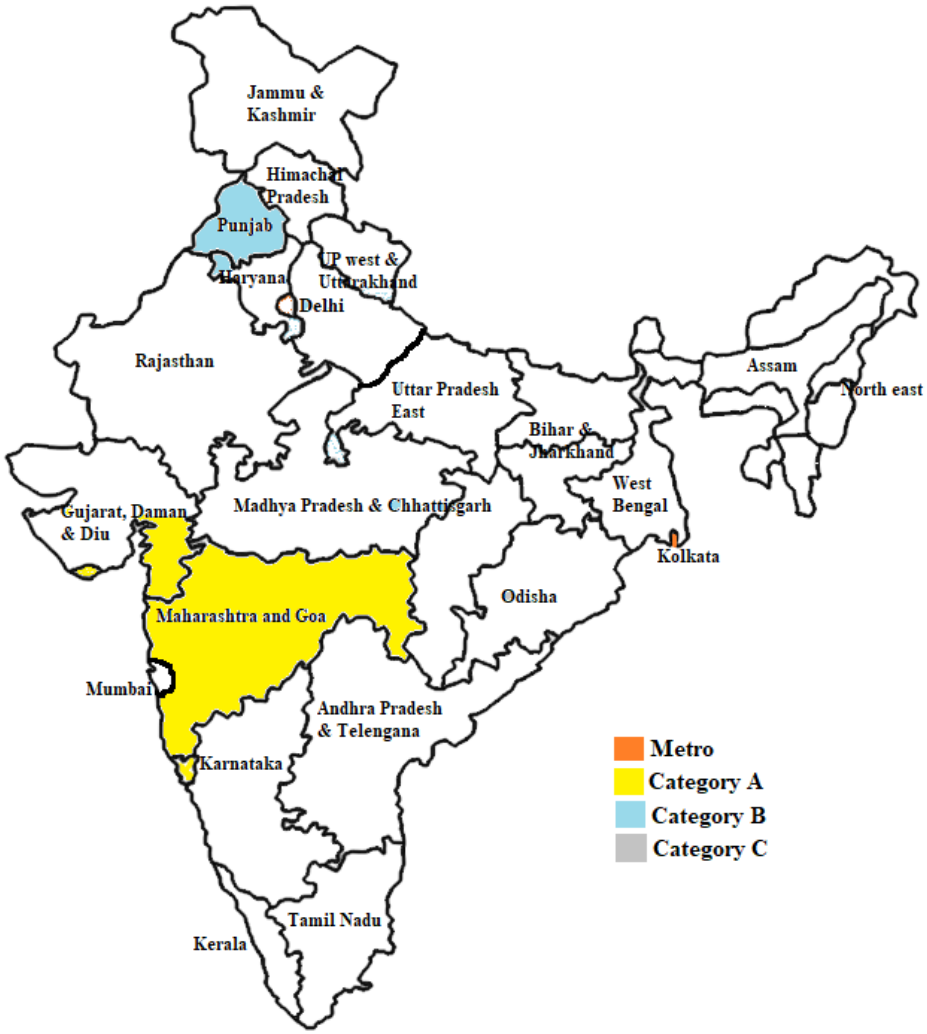
◂ data pattern 3

Jio

	LYF handsets				Jio bundle				Jio Stand-Alone Plan
Quarter	#handsets	Quantity	Market Share	Within-4G Share	#handsets	Quantity	Market Share	Within-4G Share	Market Share
2015Q4	1	198,972	0.1%	2.2%					
2016Q1	7	1,545,400	1.1%	12.5%					
2016Q2	8	1,226,209	0.9%	9.5%					
2016Q3	8	2,182,501	1.6%	11.7%					0.8%
2016Q4	6	1,225,272	0.9%	6.3%					2.9%
2017Q1	3	462,857	0.3%	2.1%					3.7%
2017Q2									4.4%
2017Q3					9	2,719,100	2.0%	8.3%	4.5%
2017Q4					8	15,473,620	11.2%	39.6%	0.2%
2018Q1					10	21,132,740	12.4%	50.2%	1.0%
2018Q2					9	14,219,938	8.3%	36.2%	3.5%

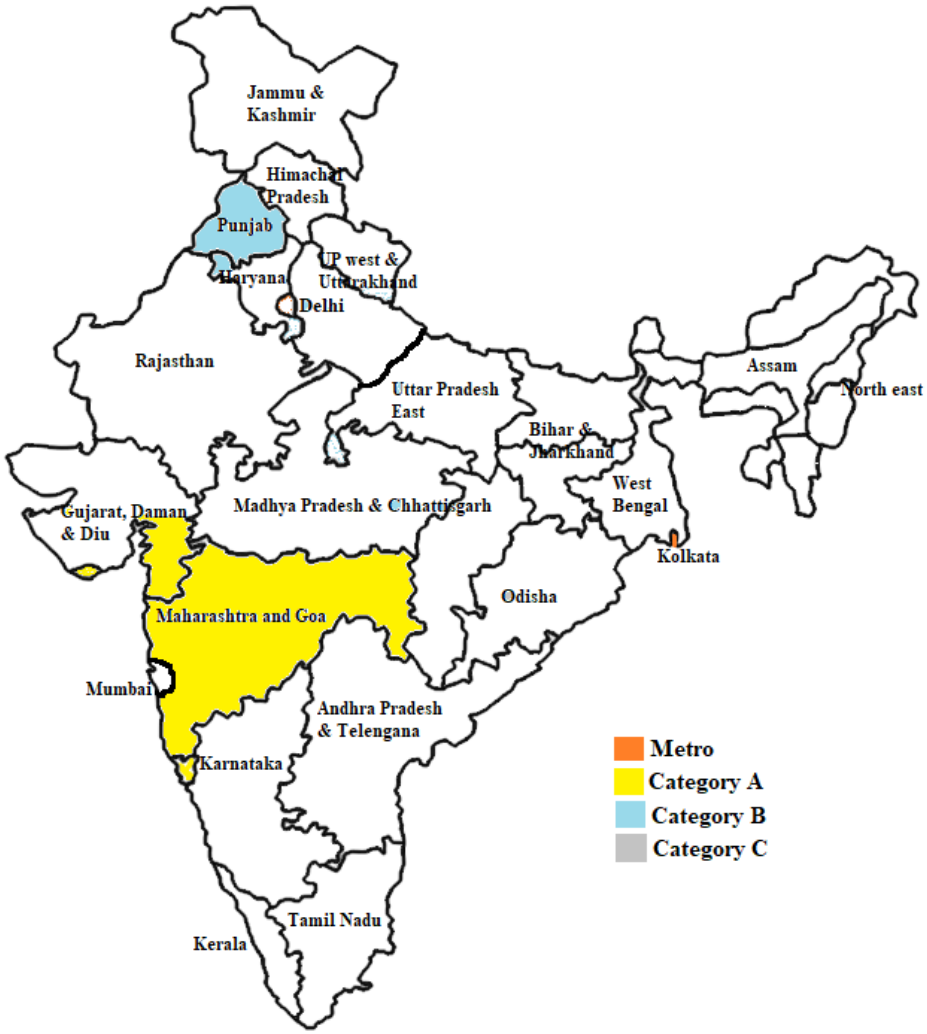
Airtel's 4G Network Expansion

2013Q1



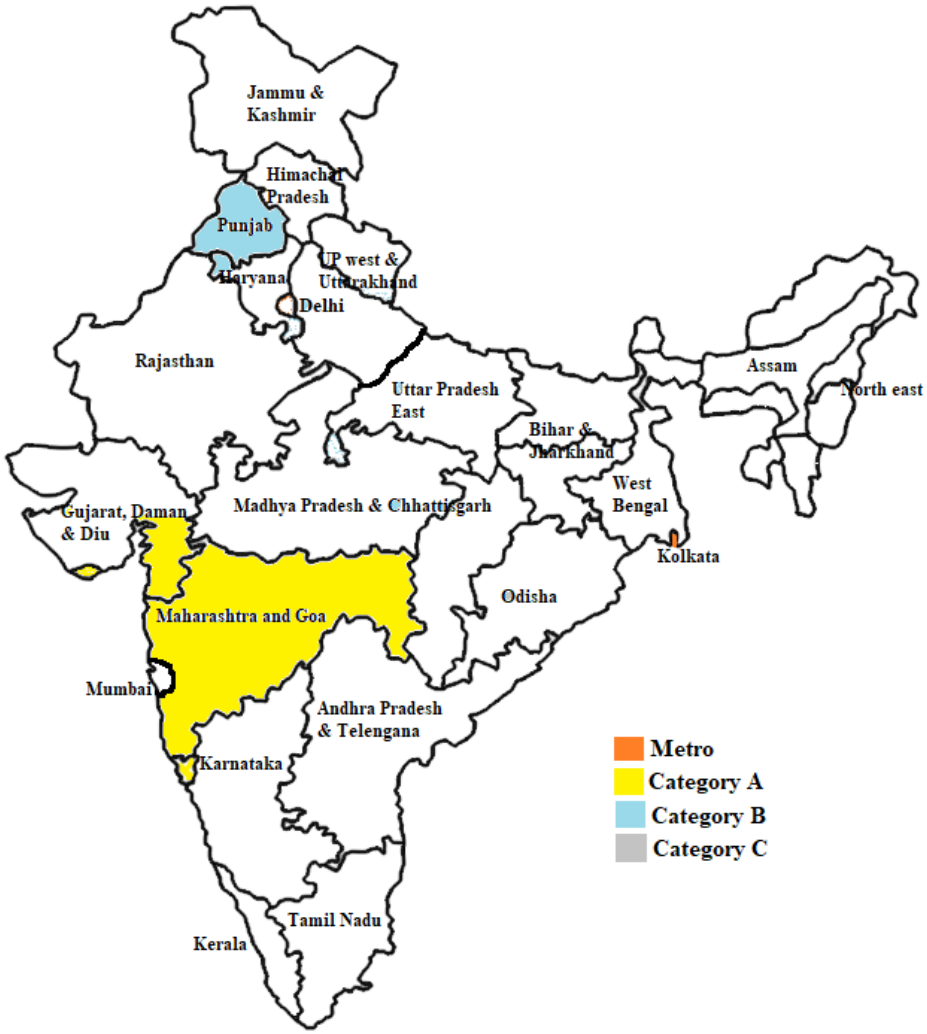
Airtel's 4G Network Expansion

2013Q2



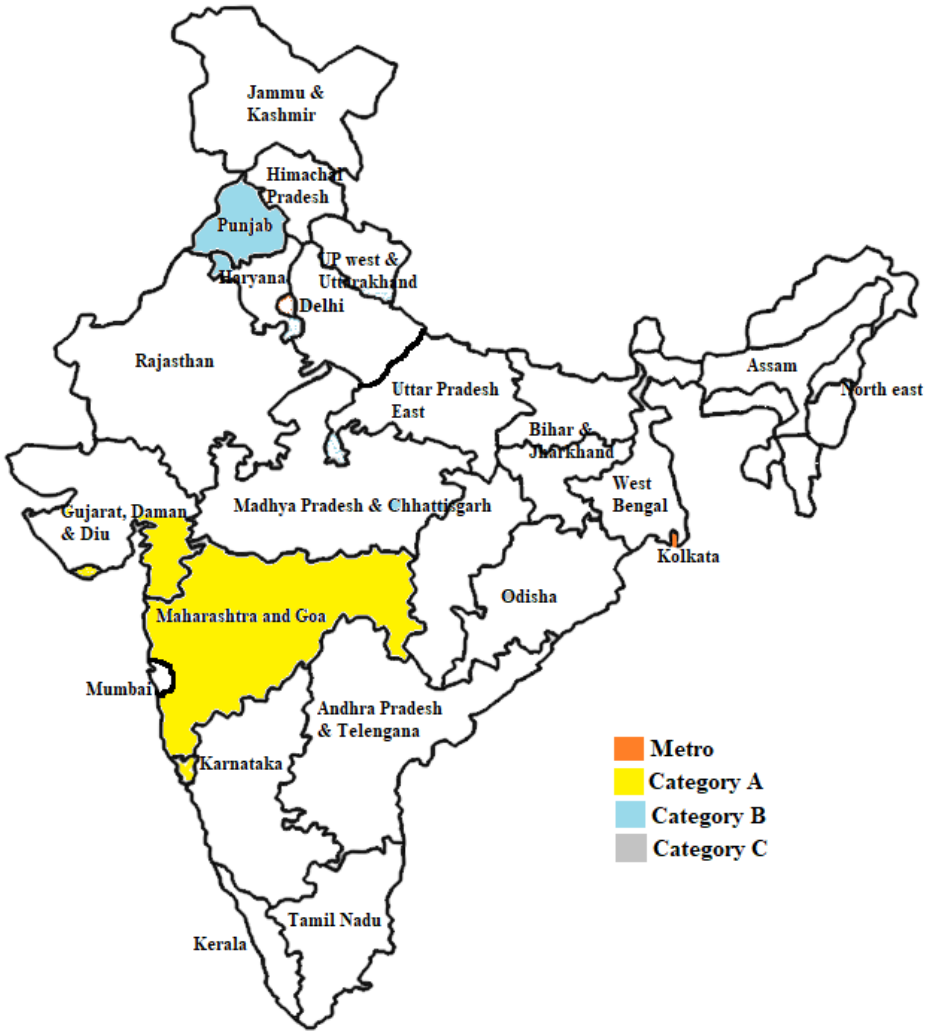
Airtel's 4G Network Expansion

2013Q3



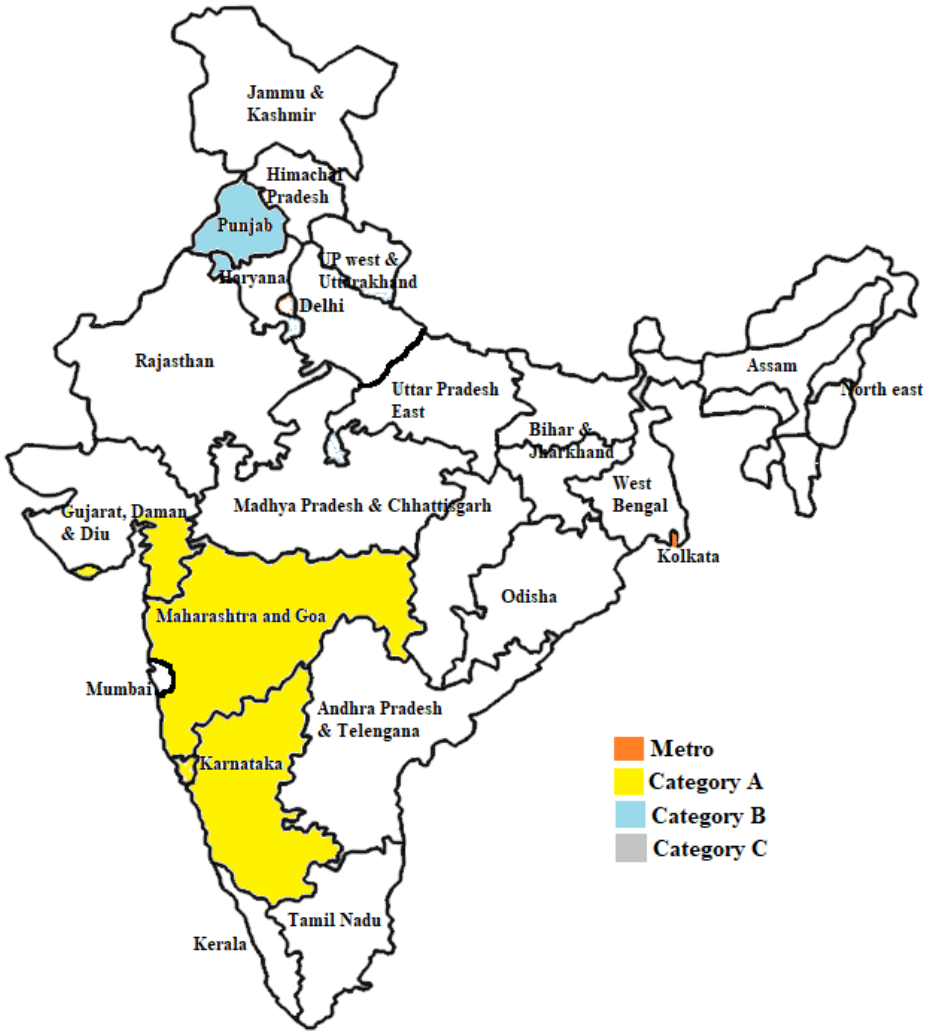
Airtel's 4G Network Expansion

2013Q4



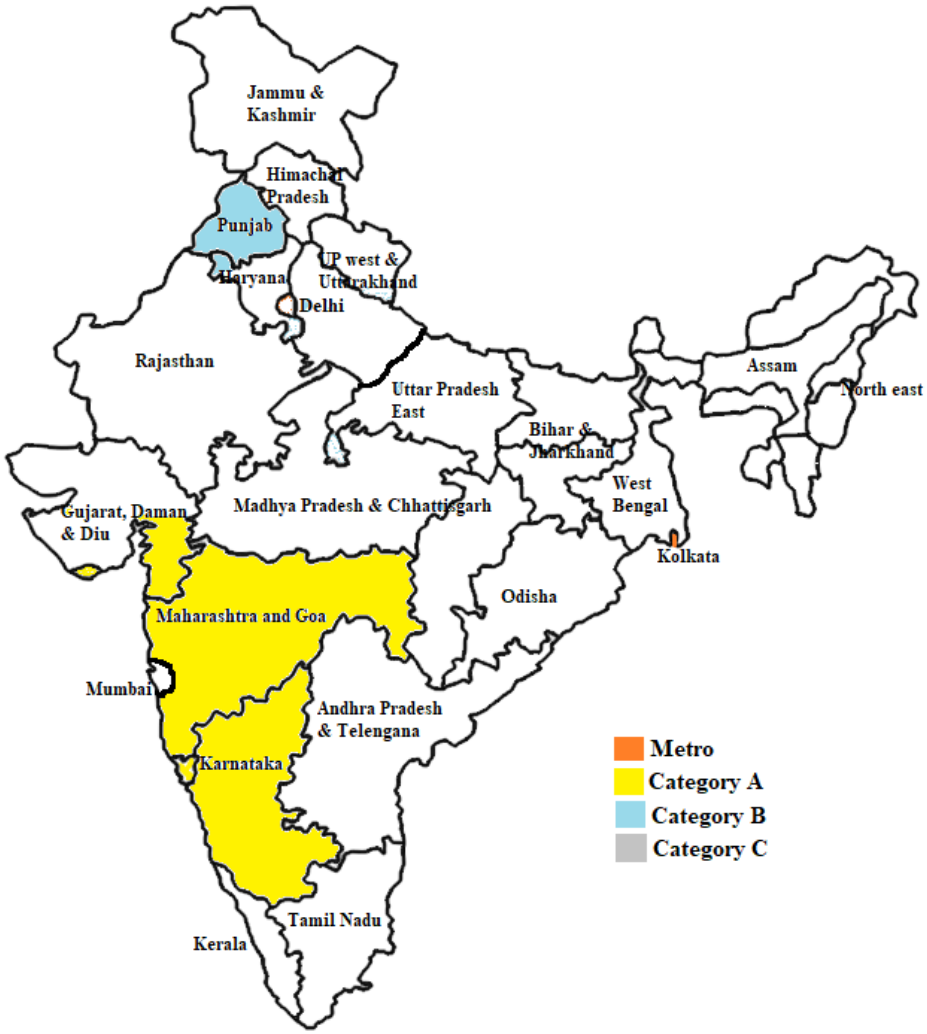
Airtel's 4G Network Expansion

2014Q1



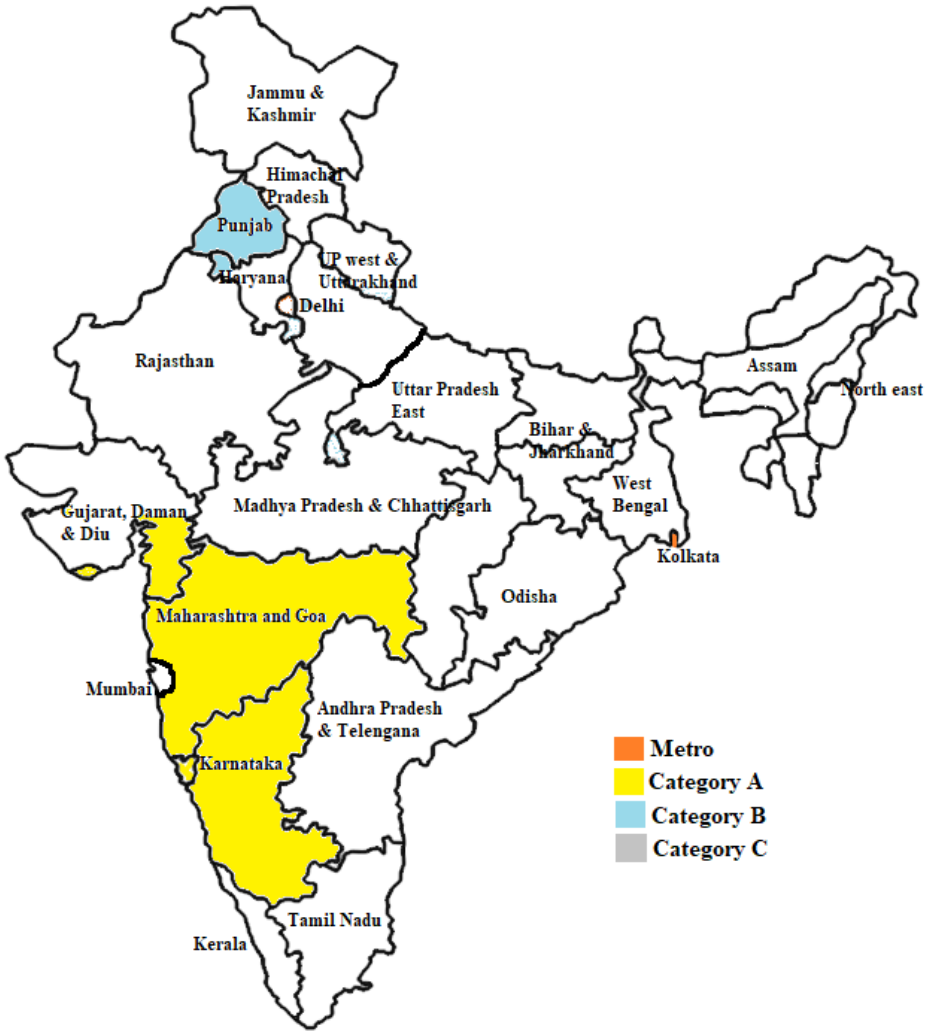
Airtel's 4G Network Expansion

2014Q2



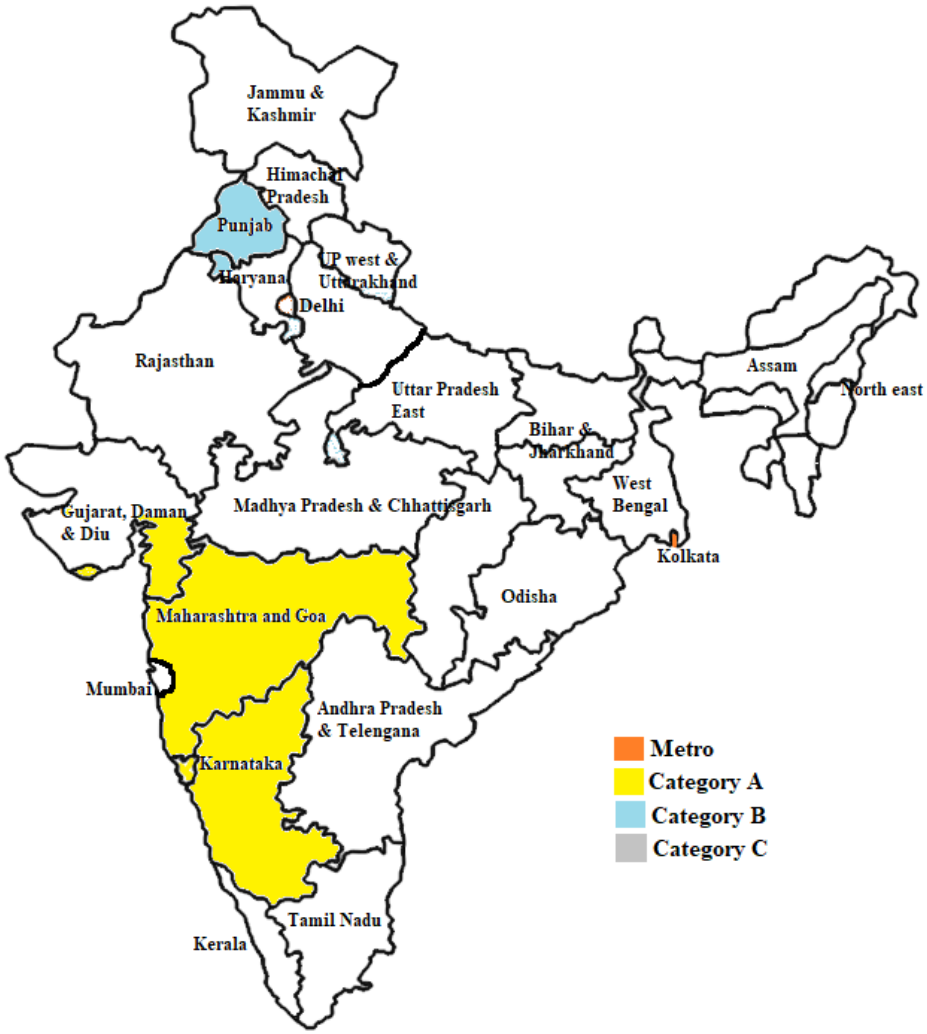
Airtel's 4G Network Expansion

2014Q3



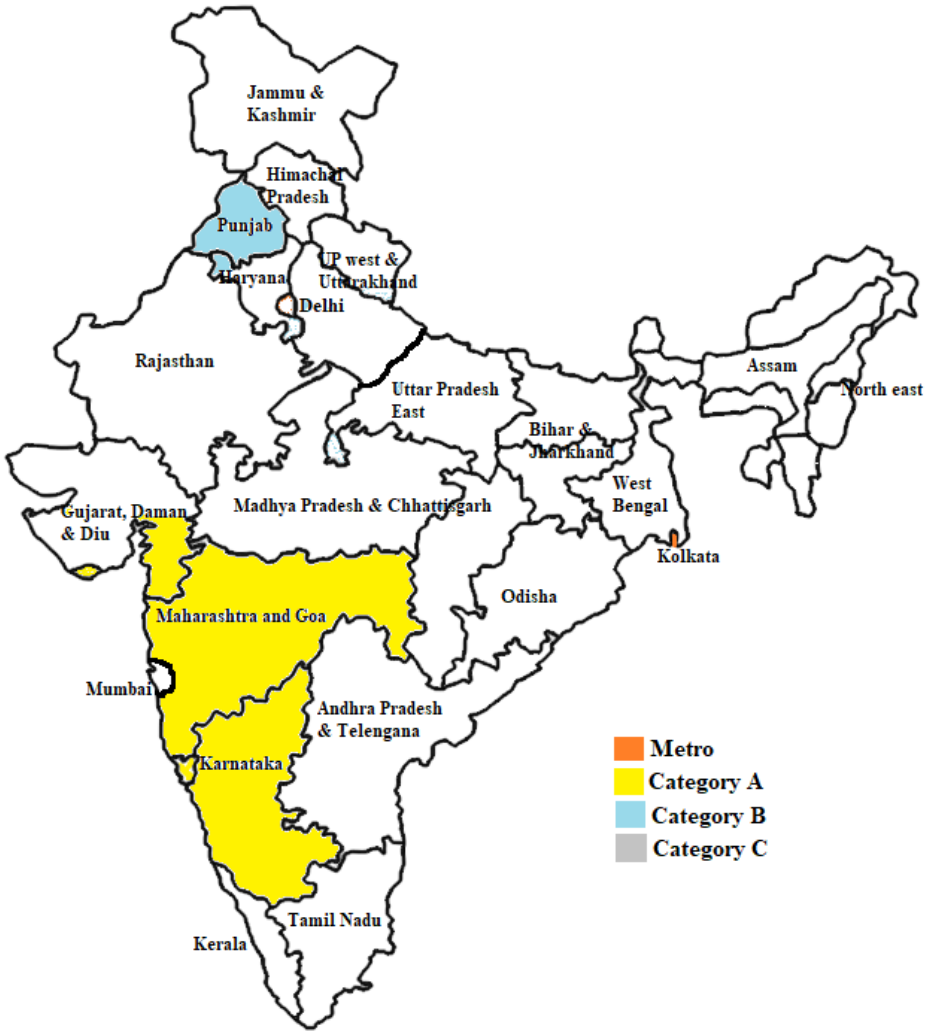
Airtel's 4G Network Expansion

2014Q4



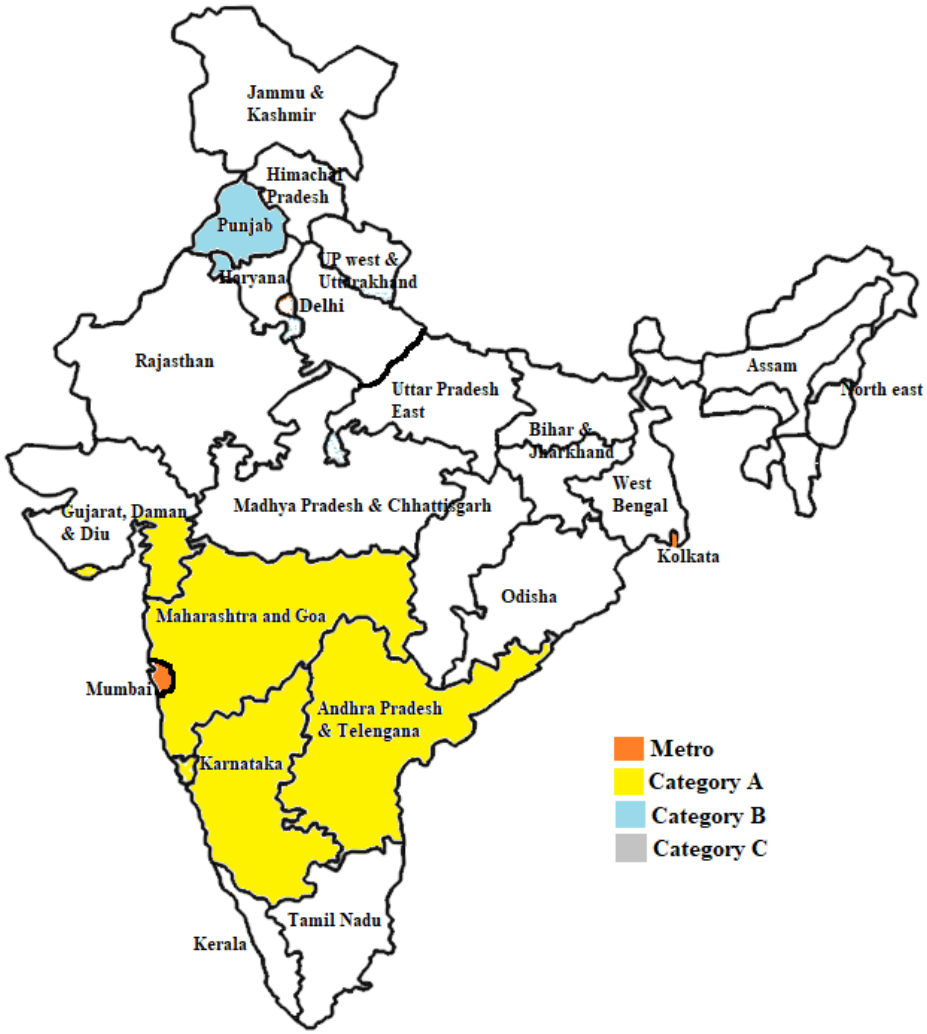
Airtel's 4G Network Expansion

2015Q1



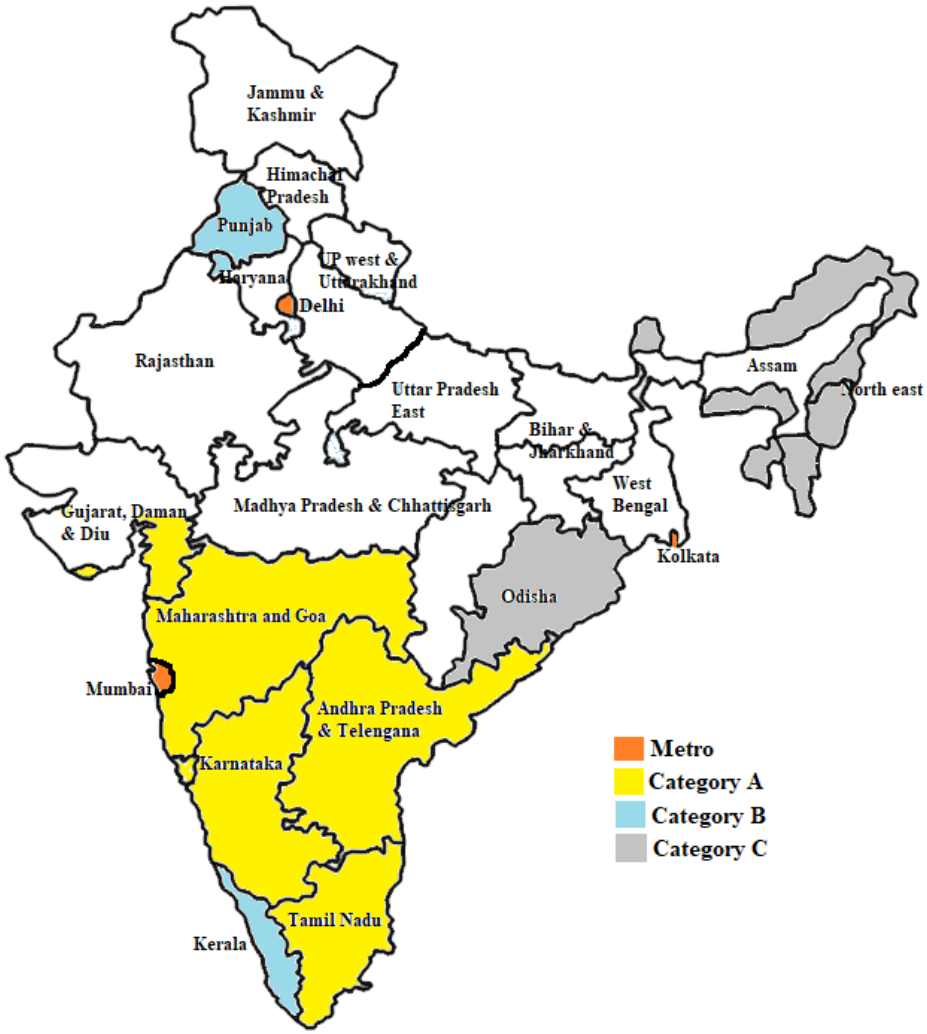
Airtel's 4G Network Expansion

2015Q2



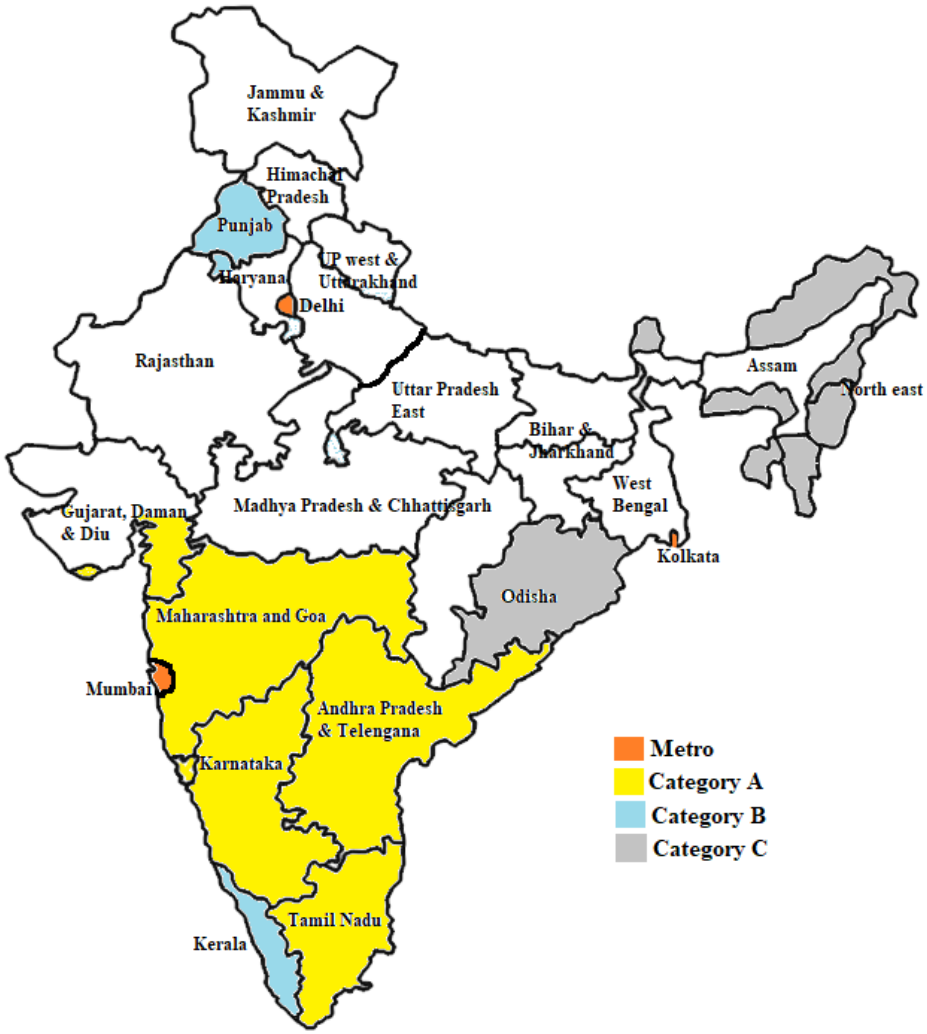
Airtel's 4G Network Expansion

2015Q3



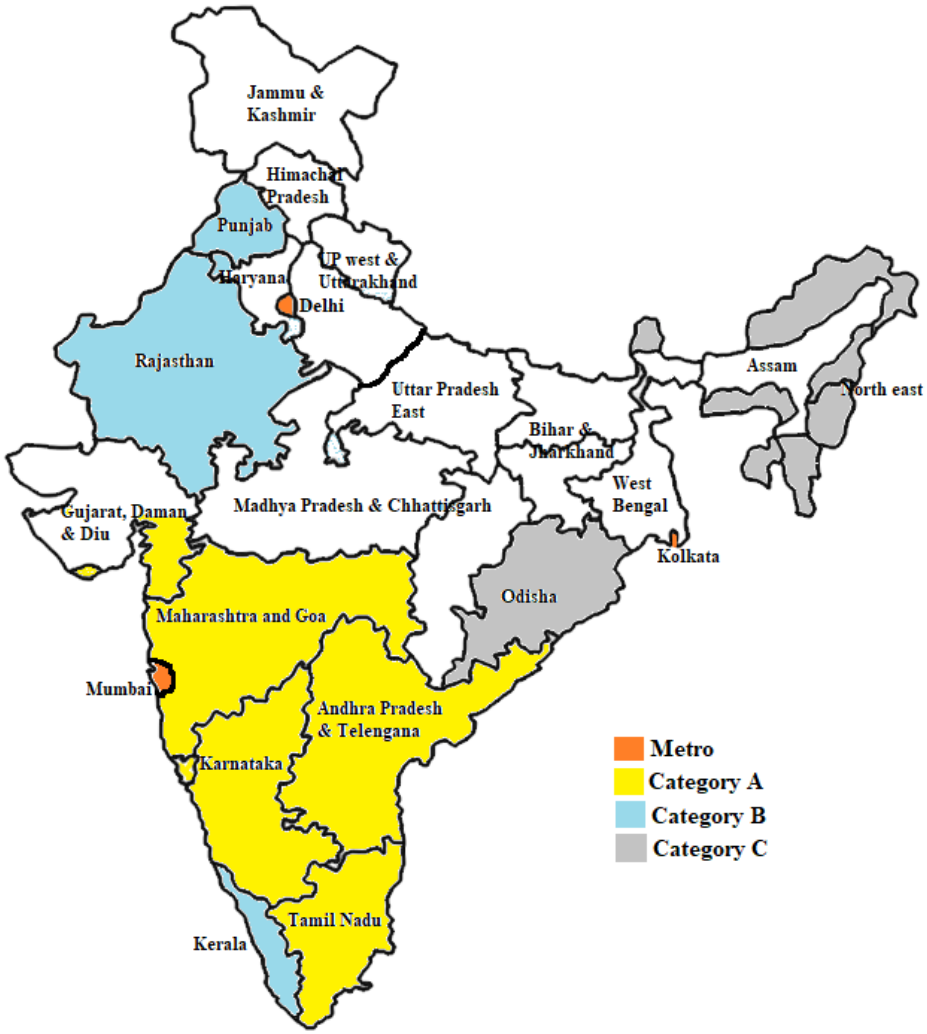
Airtel's 4G Network Expansion

2015Q4



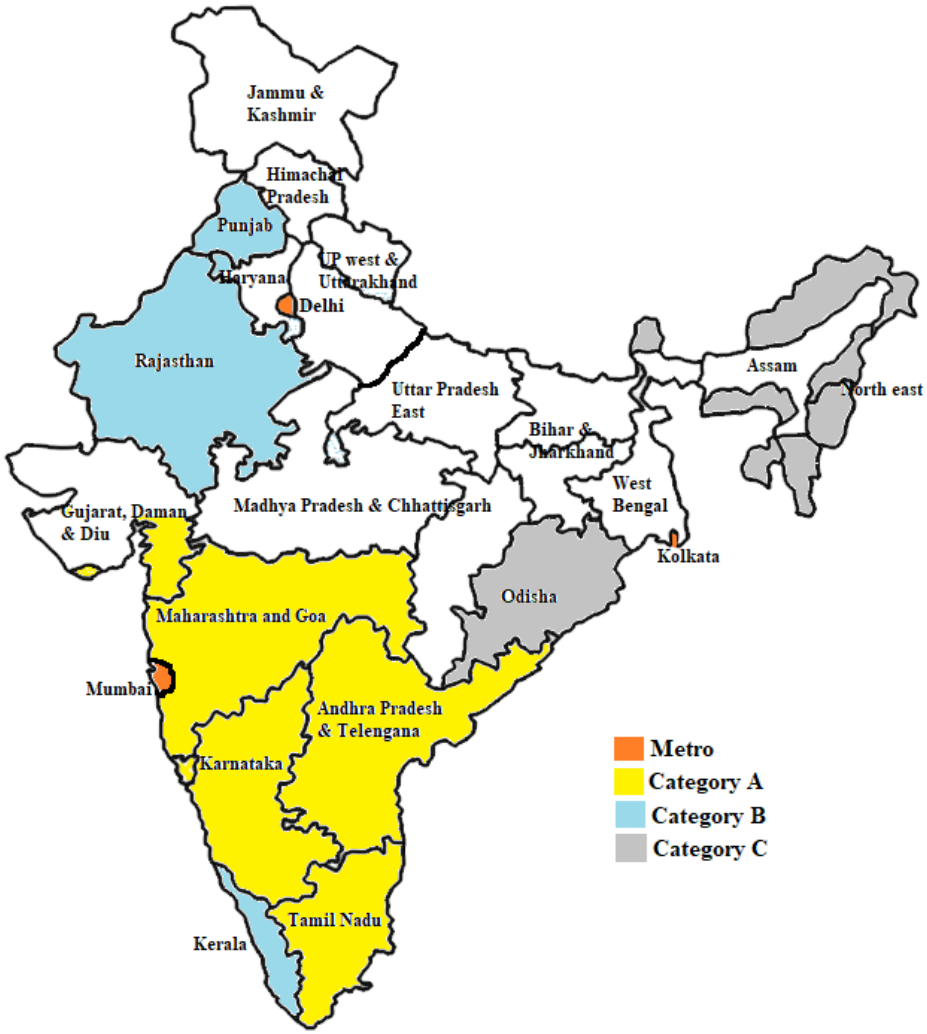
Airtel's 4G Network Expansion

2016Q1



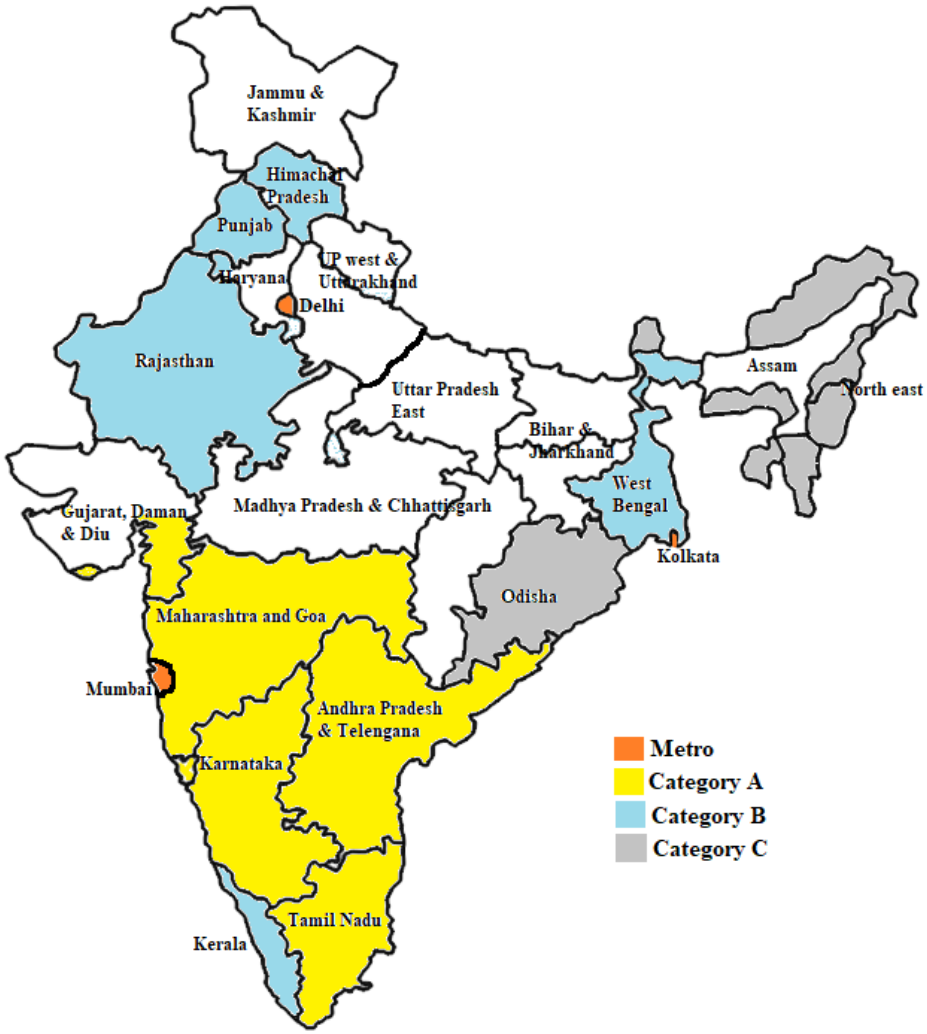
Airtel's 4G Network Expansion

2016Q2



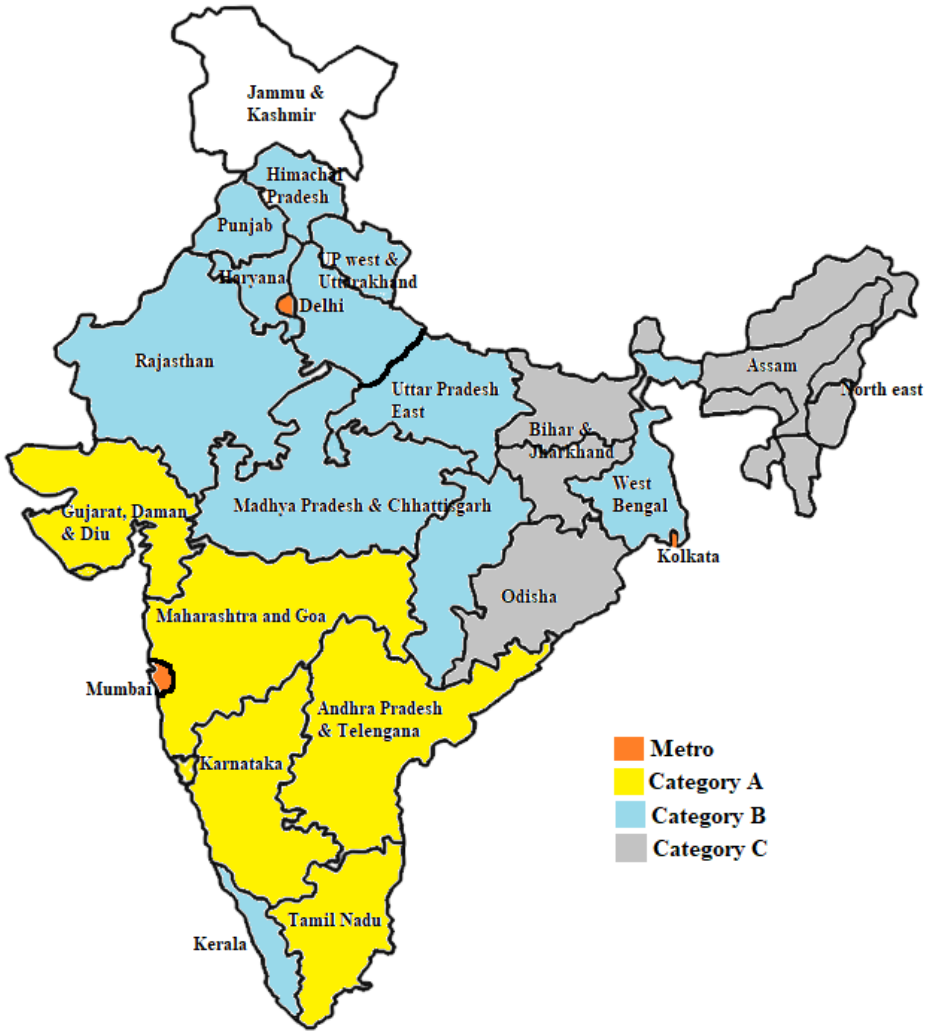
Airtel's 4G Network Expansion

2016Q3



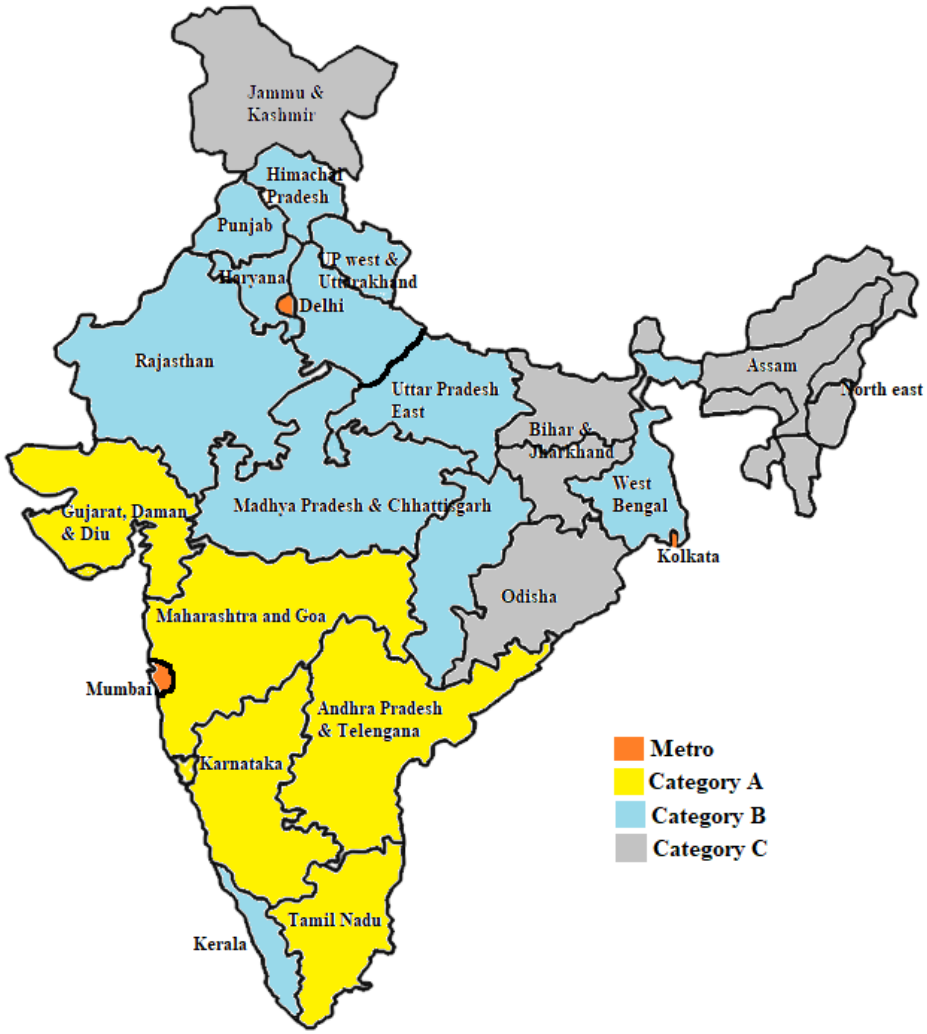
Airtel's 4G Network Expansion

2016Q4



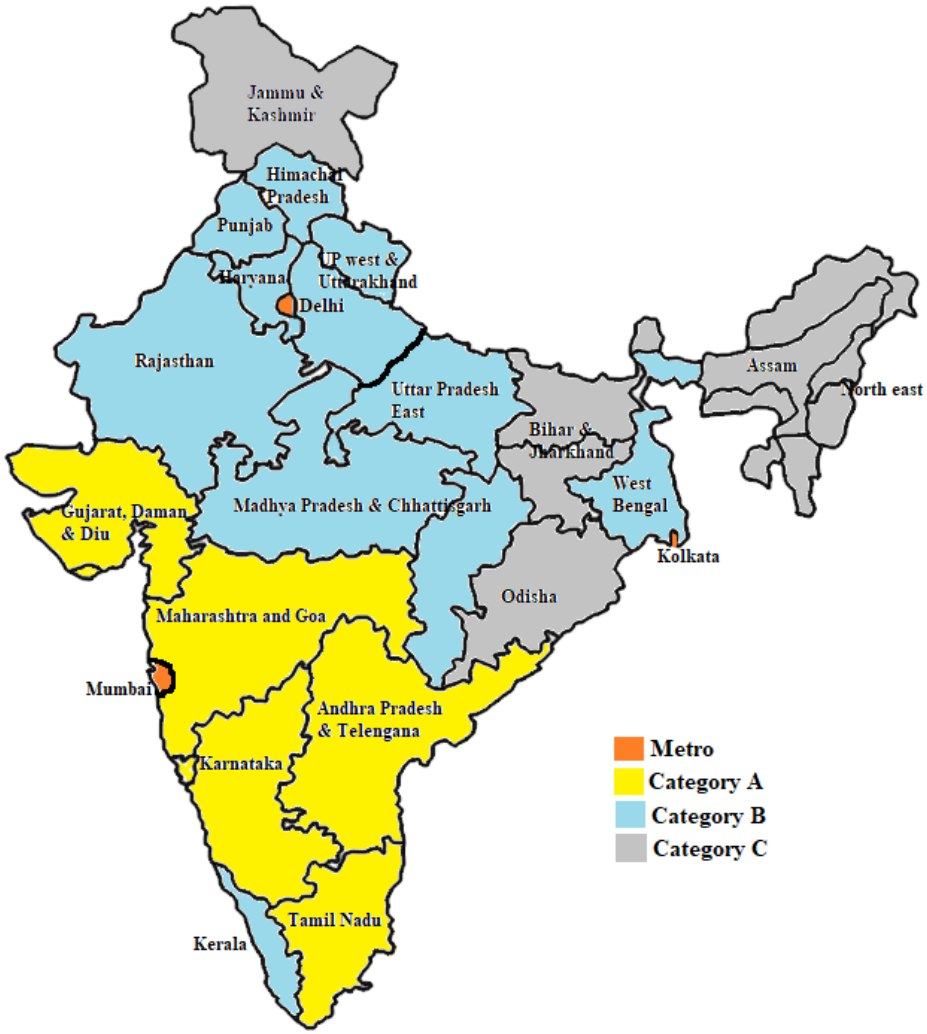
Airtel's 4G Network Expansion

2017Q1



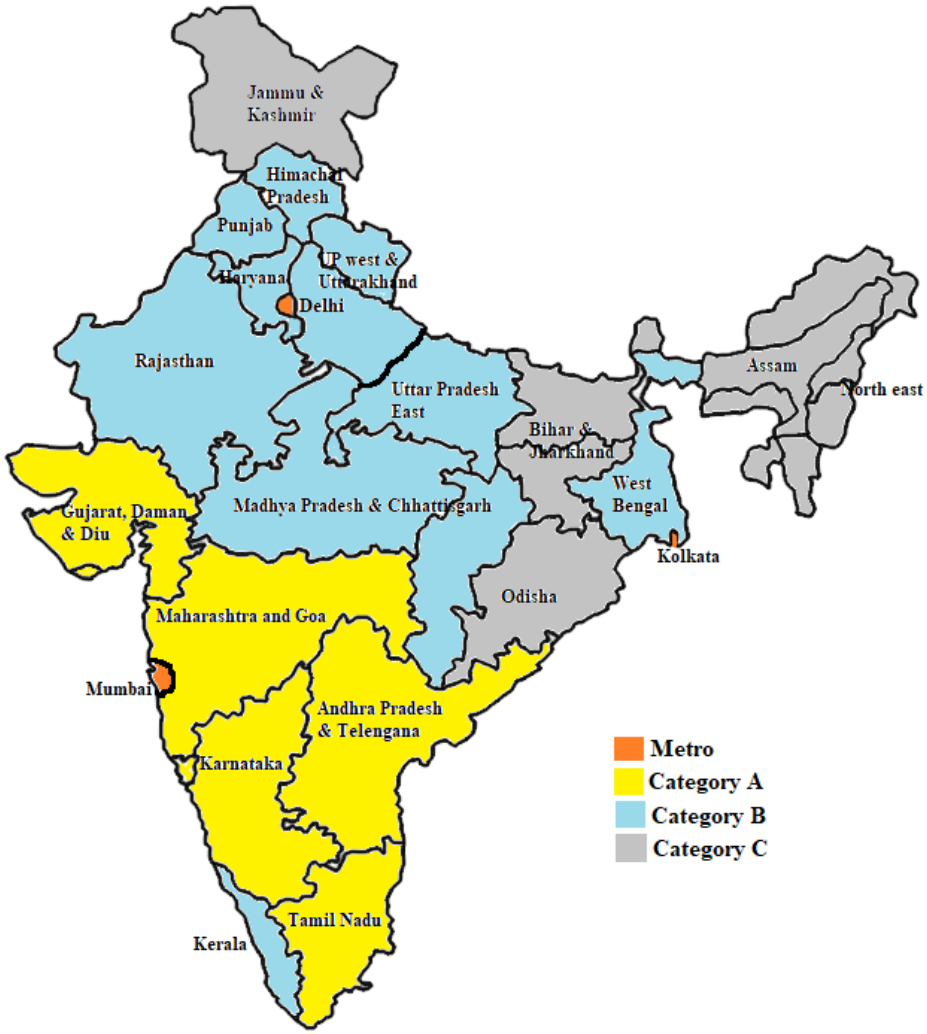
Airtel's 4G Network Expansion

2017Q2



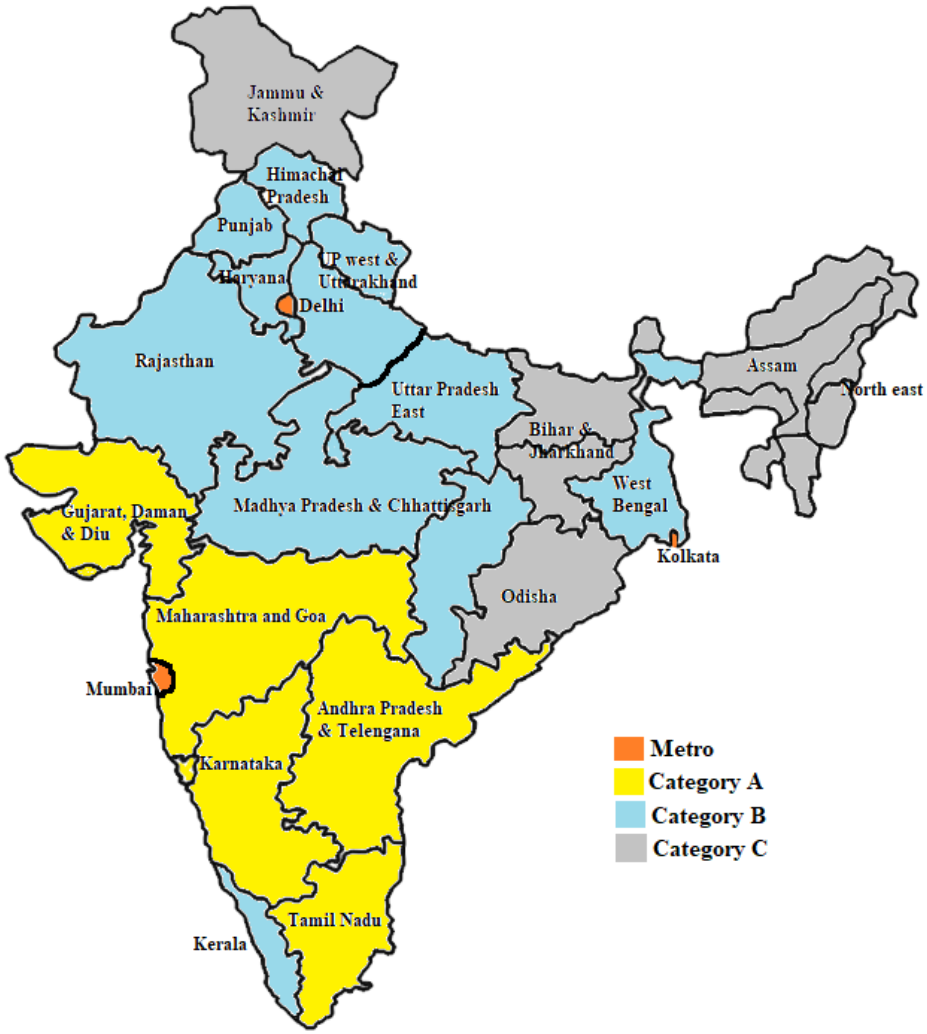
Airtel's 4G Network Expansion

2017Q3



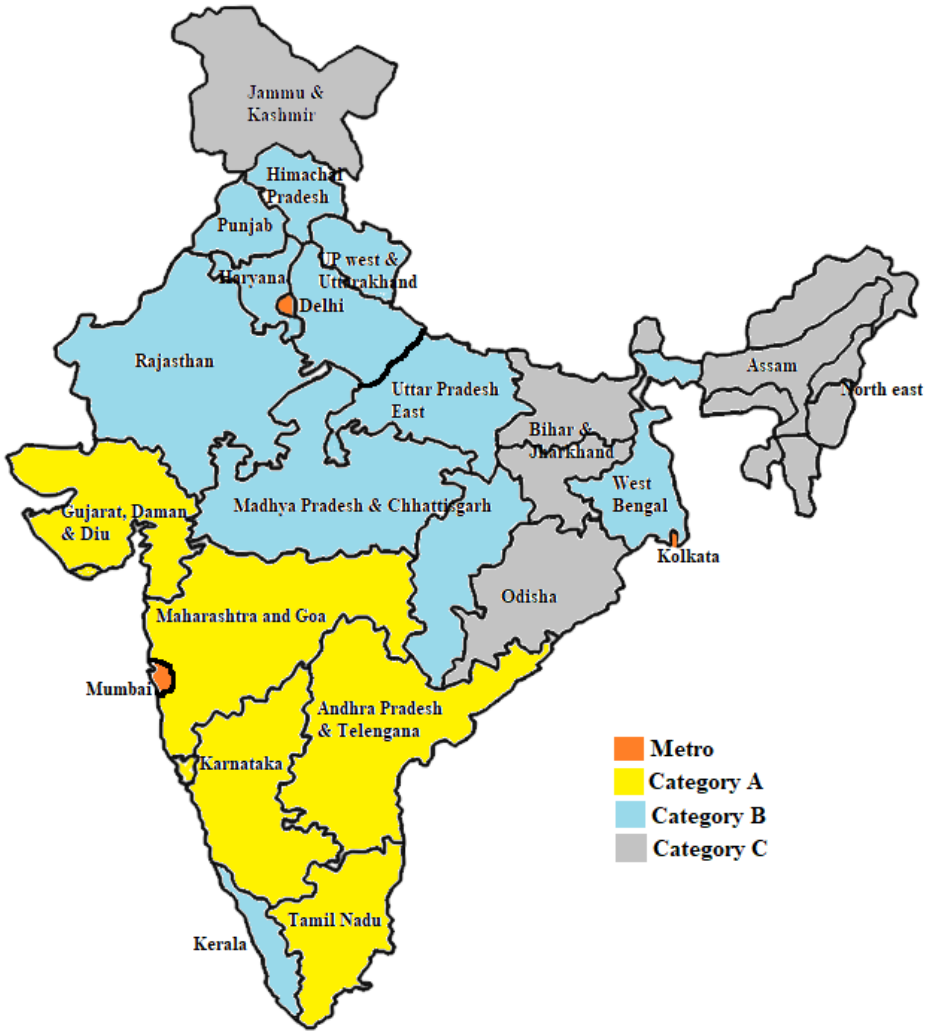
Airtel's 4G Network Expansion

2017Q4



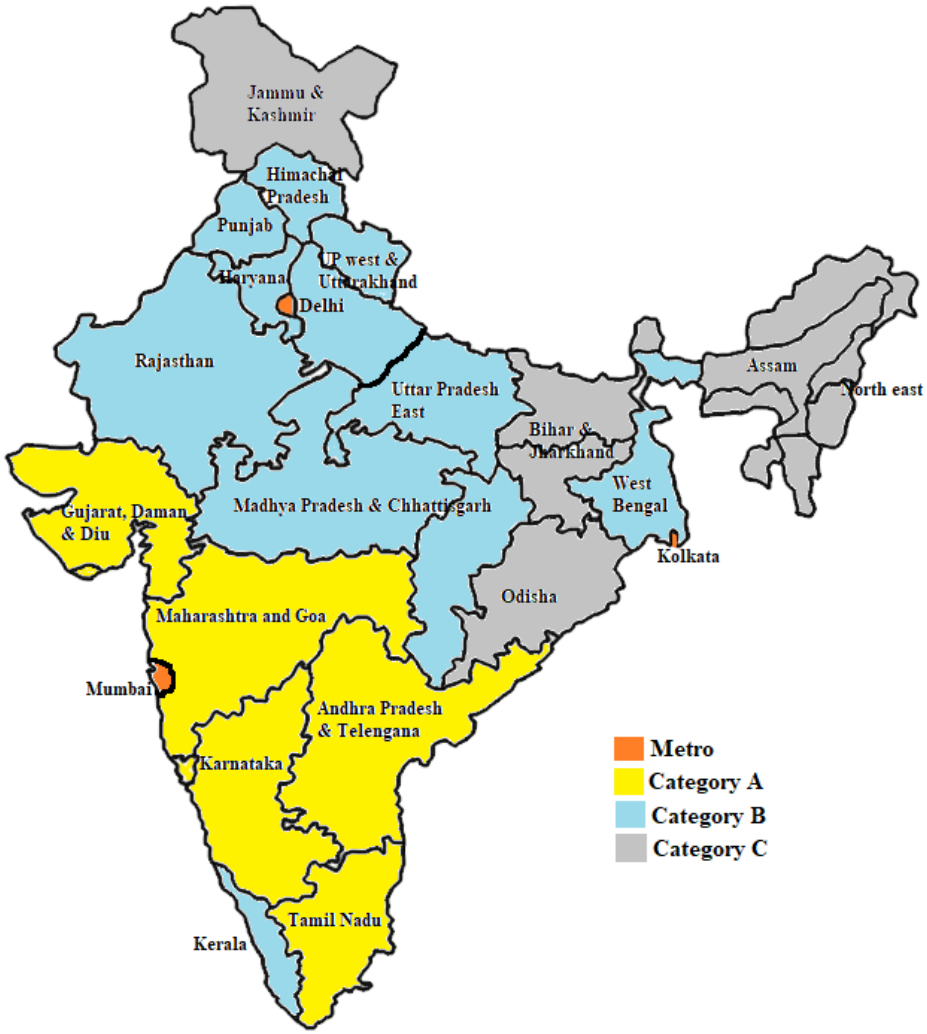
Airtel's 4G Network Expansion

2018Q1



Airtel's 4G Network Expansion

2018Q2



Spectrum Auctions

- Annual auctions between 2010 and 2016, and then in 2021
- Each auction corresponds to a specific spectrum of frequencies and specific geographic blocks
- Carriers seem not constrained: in 2015, 11% of the spectrum offered was unsold; in 2016, 60%

Spectrum usage charges

- Spectrum usage charges (SUC)
  - Prior to 2015: flat rate of 5% of the Adjusted Gross Revenue (AGR)
  - 2016–2017: In October 2016, the Department of Telecommunications announced a new formula for calculating SUC based on a weighted average formula, which varied depending on the amount of spectrum held and the brands of spectrum used. In July 2017, the Telecom Commission approved the weighted average formula.
  - 2018: flat rate of 3% of AGR for spectrum acquired in future auctions
- A carrier's profit function: (price*(1-SUC)–mc)*quantity(prices)
  - Our estimated mc is "mc/(1-SUC)"

Carriers

Airtel
Vodafone
Idea
BSNL (Bharat Sanchar Nigam Limited)
Reliance Jio
Reliance Communications
Aircel
MTNL (Mahanagar Telephone Nigam Limited)

Carriers

- Airtel, Jio, and Idea: domestic and owned by Indian entrepreneurs (owned by Bharti Airtel Limited, Reliance Jio and Aditya Birla Group respectively)
- BSNL and MTNL: public companies owned by Indian government
- Vodafone-India: an Indian subsidiary of UK-based parent company
- Aircel: an Indian firm started by Apollo Hospitals; Maxis Communications – a Malaysian firm held 74% stake in the firm

List of Carriers

Carrier	Total Subscribes (million)
Airtel	4485
Vodafone	3452
Idea	3061
BSNL	1701
Reliance Jio	1626
Reliance Communications	1554
Aircel	1468
MTNL	68

List of Carriers in 2018Q2

Carrier	Total Subscribes (million)
Reliance Jio	517
Airtel	341
Idea	218
Vodafone	218
BSNL	113
Aircel	73
MTNL	3.5

Online vs. Offline Handset Sales

January 2018 - June 2018

Origin	Handset Firm	Online	Offline
Indian	Intex	7%	93%
	Lava	1%	99%
	LYF	38%	62%
	Micromax	4%	96%
Other-Asian	Gionee	1%	99%
	Lenovo	71%	29%
	Oppo	4%	96%
	Samsung	15%	85%
	Vivo	4%	96%
	Xiaomi	67%	33%
Non-Asian	Apple	39%	61%
	Microsoft/Nokia	28%	72%

Data Details

- 2011 – 2018Q2
- Handset data
  - 2011–2014: product/year level; 2015Q1–2018Q2: product/quarter level
  - price and sales from Counterpoint Research
  - product characteristics – hand collected
- Wireless service data
  - carrier/technology-level (e.g., Airtel's 4G service). Define: plan = carrier/technology
  - sales (plan/quarter-level) and price (carrier/quarter-level) from the GSMA Intelligence
  - availability in each region – hand collected: plan/quarter/region level ▸ video

Summary Statistics: Handsets

Summary Statistics – Handsets

	Mean	S.D.	Min	Max
Price (INR)	11,795	11,193	1,329	86,002
Sales (Million)	0.27	0.46	0.03	8.12
Screen size (Inch)	4.6	0.9	2.0	6.4
Camera (Megapixel)	11.4	7.8	0.3	41.0
Internal Memory (GB)	15	17	0.0	128
RAM (GB)	1.5	1.1	0.0	6.0
Battery Capacity (mAh)	2,337	884	800	5,300
Number of Obs		1,429		

Note: This table reports the summary statistics of 3G and 4G handsets. Between 2011 and 2014, one observation is a handset/year. Between 2015Q1 and 2018Q2, one observation is a handset/quarter. We divide the annual sales between 2011 and 2014 by 4 in reporting the summary statistics about sales.

We lump all 2G handsets into one option of "2G handsets". The average quarterly sales of 2G handsets is 33.13 million.

Summary Statistics: 4G Handsets

Summary Statistics – 4G Handsets

	Mean	S.D.	Min	Max
Price (INR)	13,257	12,670	1,329	86,002
Sales (Million)	0.36	0.58	0.04	8.12
Screensize (Inch)	5.0	0.8	2.4	6.4
Camera (Megapixel)	15.6	7.5	0.3	41.0
Internal Memory (GB)	22	18	4.0	128
RAM (GB)	2.1	1.1	0.5	6.0
Battery Capacity (mAh)	2,799	793	1,300	5,300
Number of Obs		773		

Note: This table reports the summary statistics of handsets. Between 2011 and 2014, one observation is a handset/year. Between 2015Q1 and 2018Q2, one observation is a handset/quarter. We divide the annual sales between 2011 and 2014 by 4 in reporting the summary statistics about sales.

Summary Statistics: Plans

Summary Statistics – Plans

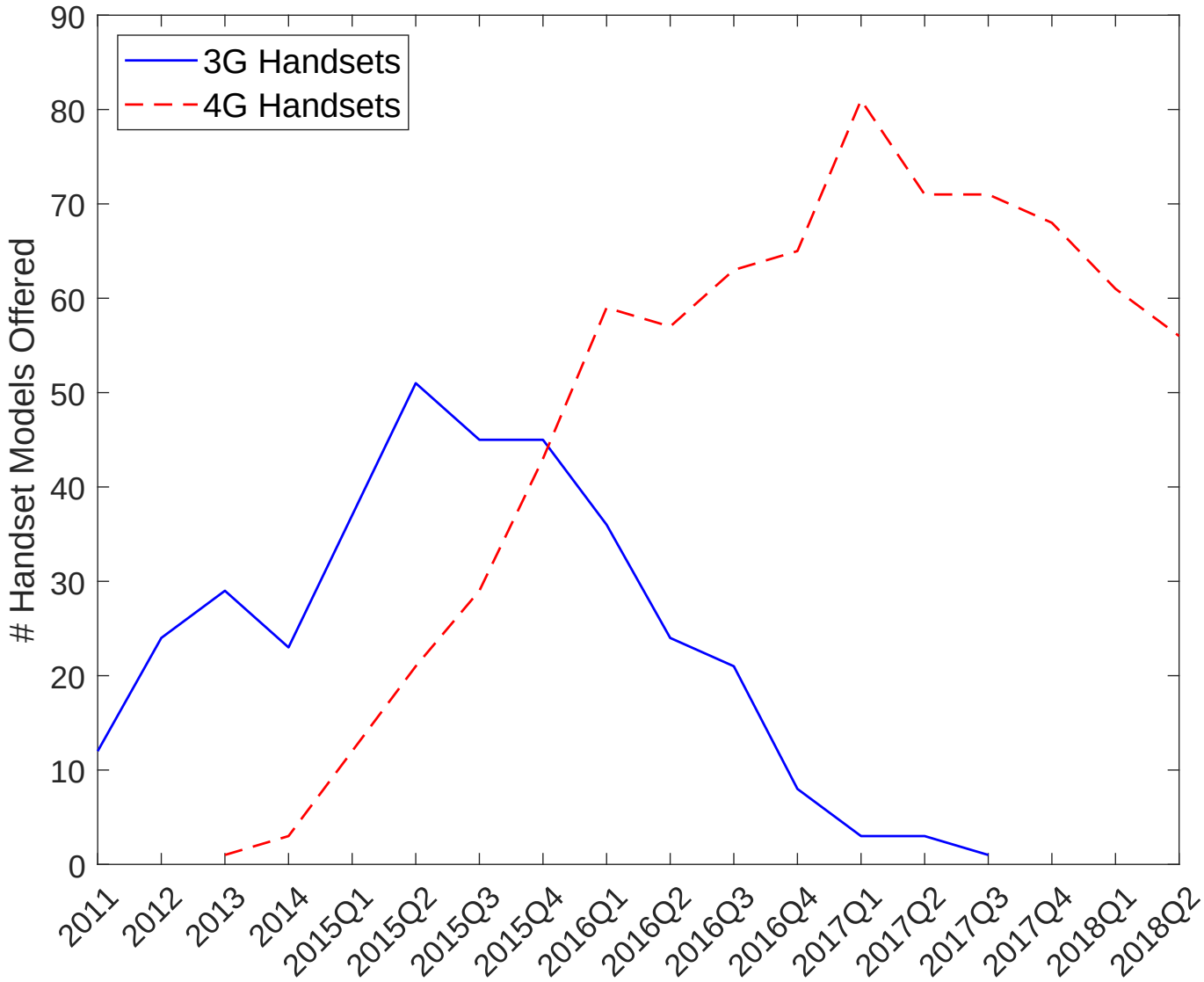
	Mean	Std	Min	Max
Monthly Price (INR)	130	45	6	207
Plan Price (INR)	2,586	915	115	4,148
# of Obs (Carrier/Quarters)		216		
Sales (Million)	54	68	0.002	517
# of Obs (Plan/Quarters)		492		

Summary Statistics: Regions

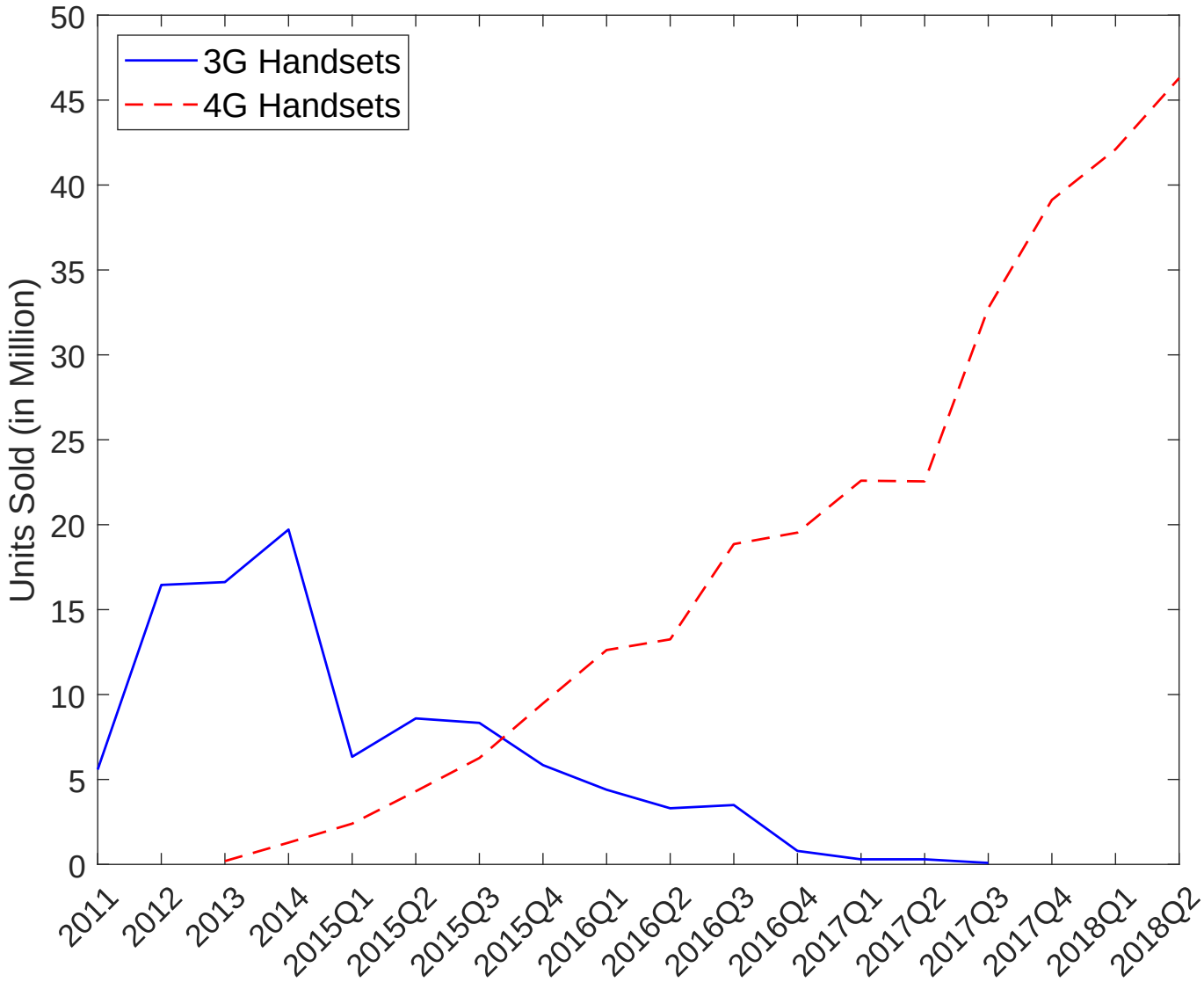
Summary Statistics – Regions

Region	Category	Population	Average Per-capita Gross State Product
Delhi	Metro	16,787,941	296,709
Kolkata	Metro	4,496,694	225,688
Mumbai	Metro	12,442,373	495,791
Andhra Pradesh & Telangana	A	84,673,556	118,678
Gujarat & Daman & Diu	A	60,626,875	137,067
Karnataka	A	61,130,704	144,777
Maharashtra & Goa	A	113,830,695	145,467
Tamil Nadu	A	72,138,958	139,201
Haryana	B	25,353,081	163,762
Kerala	B	33,387,677	146,118
Madhya Pradesh & Chhattisgarh	B	98,137,761	66,068
Punjab	B	27,704,236	117,132
Rajasthan	B	68,621,012	81,513
UP(West) & Uttarakhand	B	81,333,884	67,823
Uttar Pradesh(East)	B	128,595,209	31,698
West Bengal	B	91,347,736	75,704
Assam	C	31,169,272	58,972
Bihar & Jharkhand	C	136,770,875	37,289
Himachal Pradesh	C	6,864,602	132,110
Jammu & Kashmir	C	12,548,926	69,644
North East	C	14,418,710	84,396
Orissa	C	41,947,358	68,541

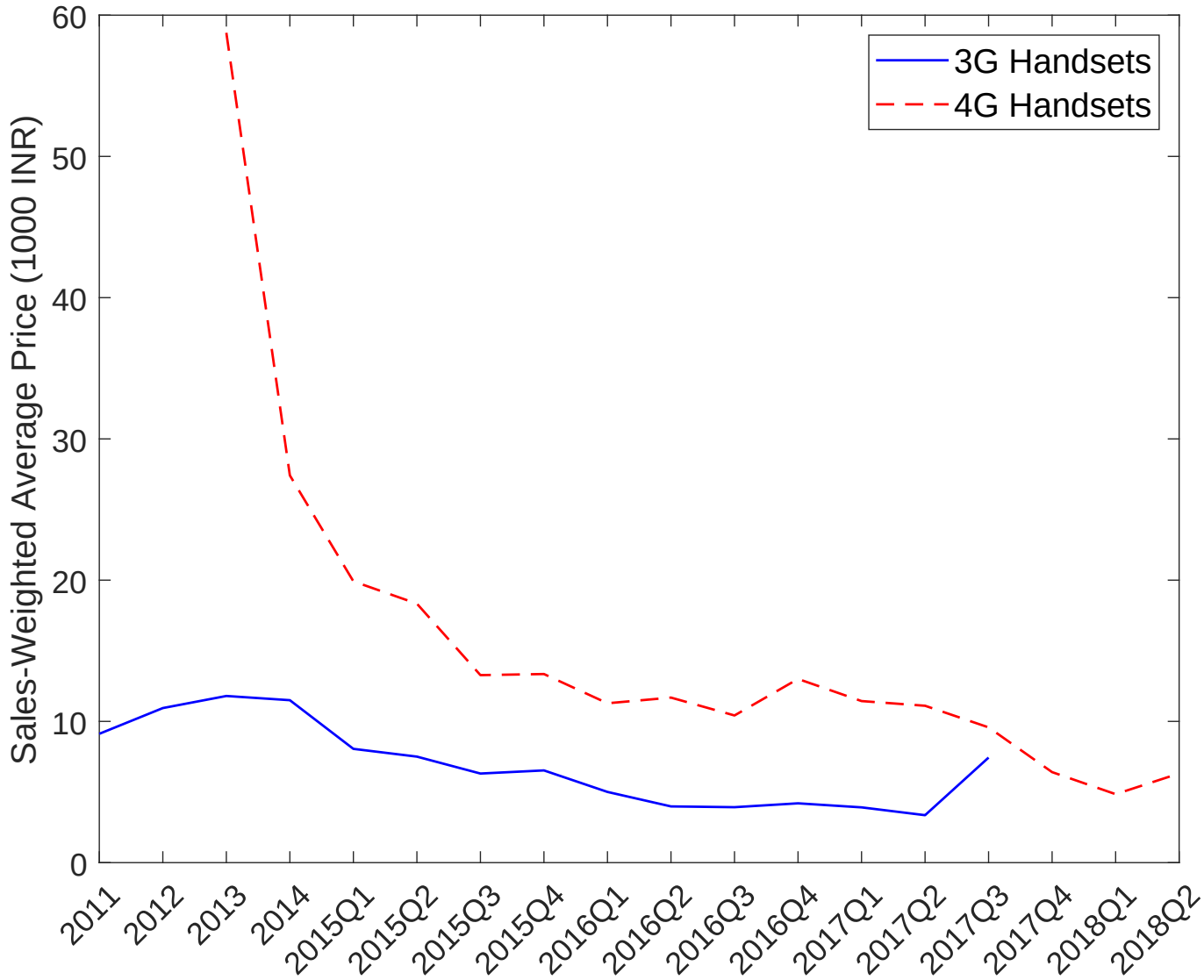
Number of Handset Models Over Time



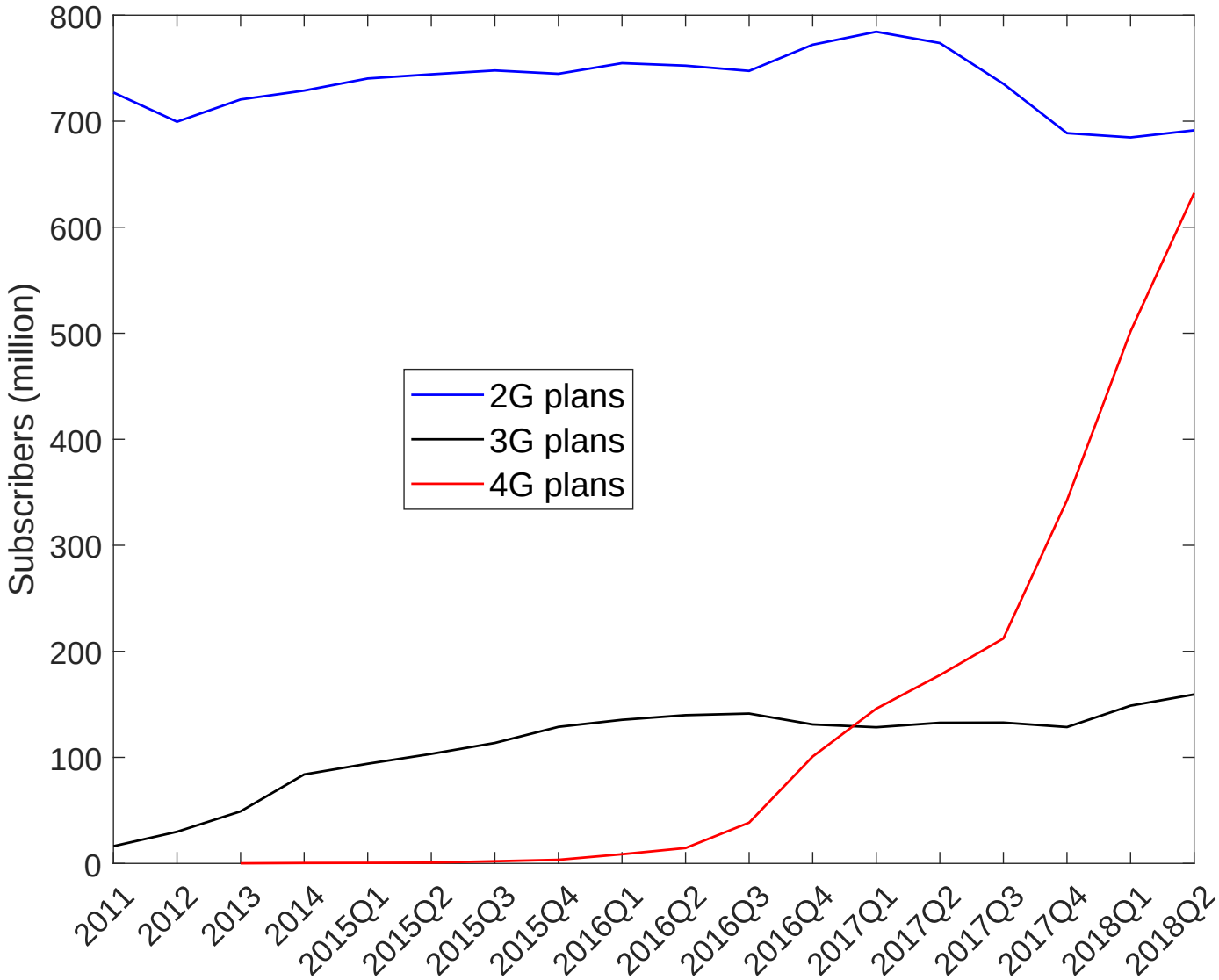
Handset Sales Over Time



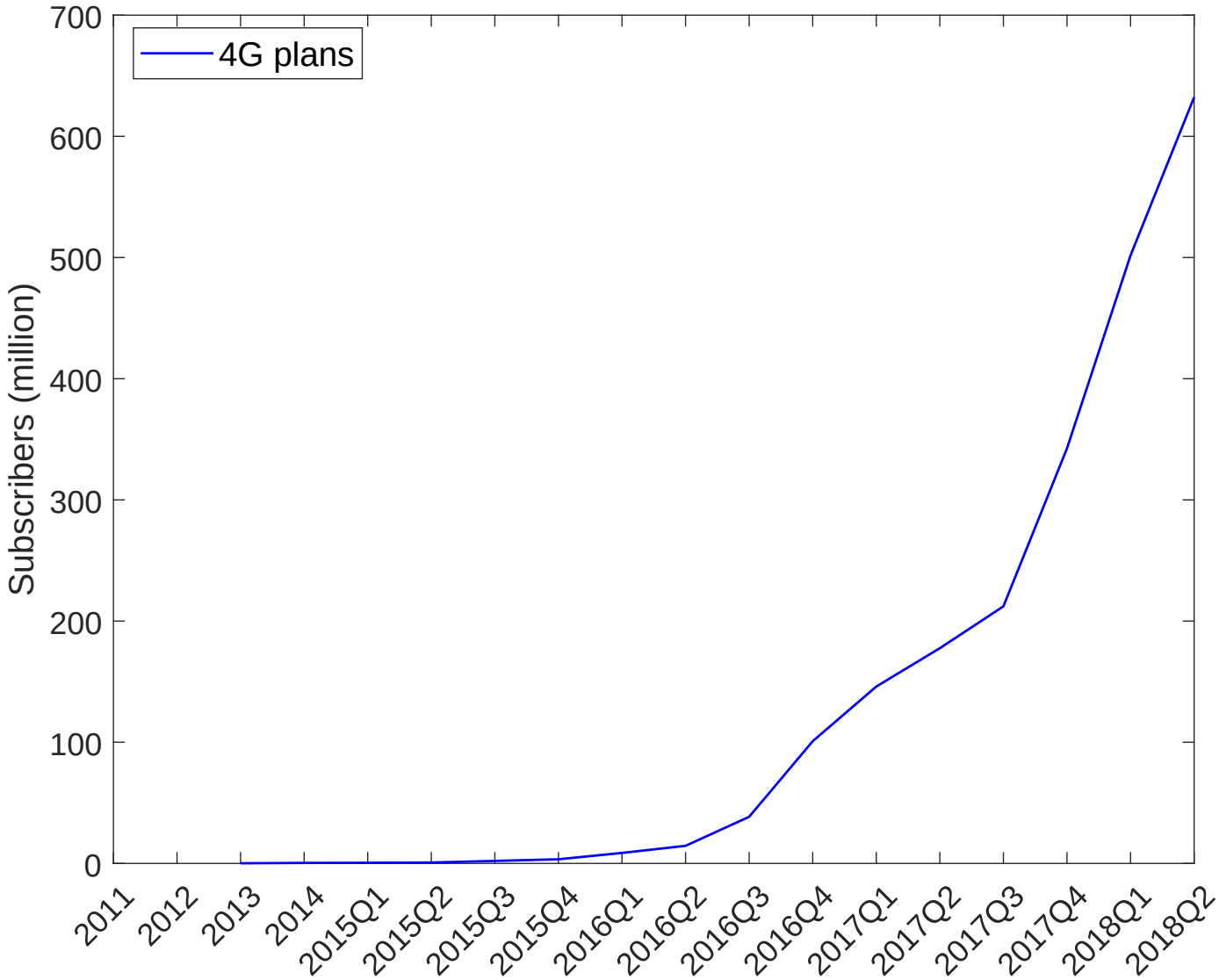
Handset Price Over Time



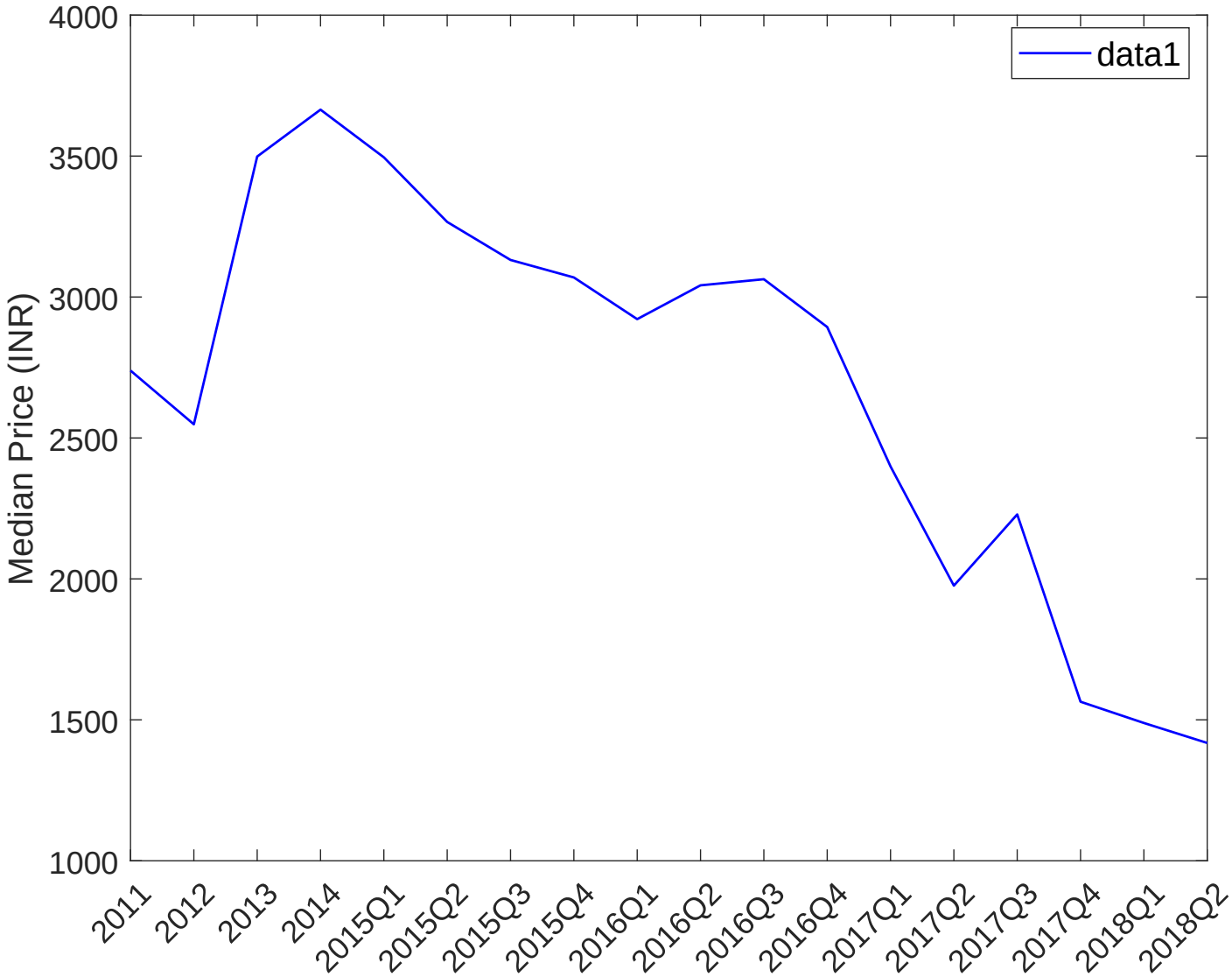
Plan Sales by Technology



4G Plan Sales Over Time



Median Plan Price Over Time



Model Details (1): Demand

- A consumer needs both a handset (indexed by j) and a wireless plan (indexed by k)
- Utility: $u_{ijkt} = \underbrace{x_{jkt}\beta_{it} - \alpha_{it}}_{\uparrow} (p_{jt} + p_{kt}) + \xi_{jt} + \zeta_{kt} + \varepsilon_{ijkt}$
  $(x_{jt}, x_{kt}, 1(4G,4G)_{jk})$
- Restrictions on the jk combination: (3G handset, 4G plan) ✗; (2G handset, 3G or 4G plan) ✗; (JioPhone, non-Jio plan) ✗
- Model implications: s_{jkrt} (market share for a combination jk in region r at time t)
- Aggregation $\Rightarrow$ Market shares: (s_{jt}, s_{kt})

Model Details (1): Demand

- A consumer needs both a handset (indexed by j) and a wireless plan (indexed by k)
- Utility: $u_{ijkt} = \underbrace{x_{jkt}\beta_{it} - \alpha_{it}}_{\uparrow} (p_{jt} + p_{kt}) + \xi_{jt} + \zeta_{kt} + \varepsilon_{ijkt}$

  $(x_{jt}, x_{kt}, 1(4G,4G)_{jk})$
- Restrictions on the jk combination: (3G handset, 4G plan) ✗; (2G handset, 3G or 4G plan) ✗; (JioPhone, non-Jio plan) ✗
- Model implications: s_{jkrt} (market share for a combination jk in region r at time t)
- Aggregation $\Rightarrow$ Market shares: (s_{jt}, s_{kt})

Model Details (1): Demand

- A consumer needs both a handset (indexed by j) and a wireless plan (indexed by k)
- Utility: $u_{ijkt} = \underbrace{x_{jkt}\beta_{it} - \alpha_{it}}_{\uparrow} (p_{jt} + p_{kt}) + \xi_{jt} + \zeta_{kt} + \varepsilon_{ijkt}$

  $(x_{jt}, x_{kt}, 1(4G,4G)_{jk})$
- Restrictions on the jk combination: (3G handset, 4G plan) ✗; (2G handset, 3G or 4G plan) ✗; (JioPhone, non-Jio plan) ✗
- Model implications: s_{jkrt} (market share for a combination jk in region r at time t)
- Aggregation $\Rightarrow$ Market shares: (s_{jt}, s_{kt})

Model Details (1): Demand

- A consumer needs both a handset (indexed by j) and a wireless plan (indexed by k)
- Utility: $u_{ijkt} = \underset{\substack{\uparrow \\ (x_{jt}, x_{kt}, 1(4G,4G)_{jk})}}{x_{jkt}\beta_{it} - \alpha_{it}\ (p_{jt} + p_{kt})} + \xi_{jt} + \zeta_{kt} + \varepsilon_{ijkt}$
- Restrictions on the jk combination: (3G handset, 4G plan) ✗; (2G handset, 3G or 4G plan) ✗; (JioPhone, non-Jio plan) ✗
- Model implications: s_{jkrt} (market share for a combination jk in region r at time t)
- Aggregation $\Rightarrow$ Market shares: (s_{jt}, s_{kt})

Model Details (1): Demand

- A consumer needs both a handset (indexed by j) and a wireless plan (indexed by k)
- Utility: $u_{ijkt} = \underbrace{x_{jkt}\beta_{it} - \alpha_{it}}_{\uparrow} (p_{jt} + p_{kt}) + \xi_{jt} + \zeta_{kt} + \varepsilon_{ijkt}$
  $\uparrow$ $(x_{jt}, x_{kt}, 1(4G,4G)_{jk})$
- Restrictions on the jk combination: (3G handset, 4G plan) ✗; (2G handset, 3G or 4G plan) ✗; (JioPhone, non-Jio plan) ✗
- Model implications: s_{jkrt} (market share for a combination jk in region r at time t)
- Aggregation $\Rightarrow$ Market shares: (s_{jt}, s_{kt})

Model Details (2): Static Product Choice Game

Decisions	To be estimated
Stage 1. Product choice game Handset firms choose handsets given the current network	FC
Stage 2. Pricing game Handset firms choose handset prices and carriers choose plan prices given the set of handsets and plans	MC

- Details: second-stage pricing game
- Details: first-stage product choice game

Model Details (3): Dynamic 4G Network Expansion

- Dynamic: entering a region with 4G services is an absorbing state
- Finite periods: by the end of our sample, all four carriers had entered in almost all regions studied in the paper
- Four carriers: we focus on the four largest carriers that account for 95% of the 4G services

Model Details: Second-stage Pricing Game

- Handset firms: (indexed by f)

$$\max_{\boldsymbol{p}_f^{handset}} \pi_f^{handset}(\boldsymbol{p}_f^{handset}, \boldsymbol{p}_{-f}^{handset}, \boldsymbol{p}^{plan})$$

- Carriers: (indexed by c)

$$\max_{\boldsymbol{p}_c^{plan}} \pi_c^{plan}(\boldsymbol{p}^{handset}, \boldsymbol{p}_c^{plan}, \boldsymbol{p}_{-c}^{plan})$$

- Jio 2016Q3–2017Q1: a stand-alone plan (Jio 4G plan) and stand-alone handsets (under the brand name LYF)

$$\max_{\boldsymbol{p}_{LYF}^{handset}, p_{Jio}^{plan}} \pi^{plan}(\boldsymbol{p}_{LYF}^{handset}, p_{Jio}^{plan}, \boldsymbol{p}_{-LYF}^{handset}, \boldsymbol{p}_{-Jio}^{plan}) + \pi^{handset}(.,.,.,.)$$

- Jio 2017Q3–2018Q2: a stand-alone plan and bundles (Jiophones)

$$\max_{\boldsymbol{p}_{Jiophone}^{bundle}, p_{Jio}^{plan}} \pi^{plan}(\boldsymbol{p}_{Jiophone}^{bundle}, p_{Jio}^{plan}, \boldsymbol{p}^{bundle}, \boldsymbol{p}_{-Jio}^{plan}) + \pi^{bundle}(.,.,.,.)$$

Model Details: First-Stage Product Choice Game

- First-stage product-choice game: handset firms choose handsets given the current network (i.e., available plans)
- Definition of potential products
  - a product = (handset firm, 3G/4G, quality index)
  - Step 1. Define a grid of qualities: (min: gap: max)
  - Step 2. Add qualities of observed products of the same origin and technology at the time (e.g., 3G Indian handsets in 2015Q1)
  - Step 3. Remove grid points close to observed qualities

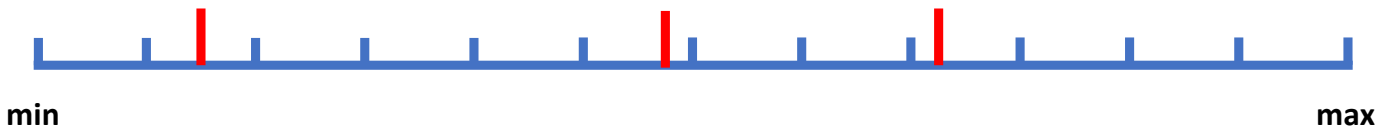
Model Details: First-Stage Product Choice Game

- First-stage product-choice game: handset firms choose handsets given the current network (i.e., available plans)
- Definition of potential products
  - a product = (handset firm, 3G/4G, quality index)

  - Step 1. Define a grid of qualities: (min: gap: max)
  - Step 2. Add qualities of observed products of the same origin and technology at the time (e.g., 3G Indian handsets in 2015Q1)
  - Step 3. Remove grid points close to observed qualities

Model Details: First-Stage Product Choice Game

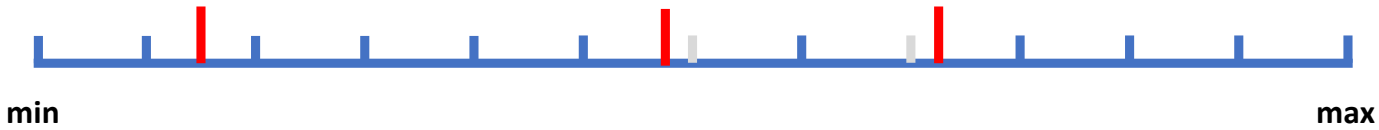
- First-stage product-choice game: handset firms choose handsets given the current network (i.e., available plans)
- Definition of potential products
  - a product = (handset firm, 3G/4G, quality index)



  - Step 1. Define a grid of qualities: (min: gap: max)
  - Step 2. Add qualities of observed products of the same origin and technology at the time (e.g., 3G Indian handsets in 2015Q1)
  - Step 3. Remove grid points close to observed qualities

Model Details: First-Stage Product Choice Game

- First-stage product-choice game: handset firms choose handsets given the current network (i.e., available plans)
- Definition of potential products
  - a product = (handset firm, 3G/4G, quality index)



  - Step 1. Define a grid of qualities: (min: gap: max)
  - Step 2. Add qualities of observed products of the same origin and technology at the time (e.g., 3G Indian handsets in 2015Q1)
  - Step 3. Remove grid points close to observed qualities

Definition of Potential Products (Cont.)

- Int'l 3G – same potential products over time
  - min = $\underline{q}_{3G} - 0.1$, max = $\bar{q}_{3G,Int'l} + 0.1$
  - Empty from 2017Q2 on (one quarter after Int'l firms stopped selling 3G handsets in India)
- Indian 3G – expanding potential products over time
  - min = $\underline{q}_{3G} - 0.1$, max = $\bar{q}_{3G,Indian,t} + 0.1$
- Int'l 4G – expanding potential products over time
  - min = $\underline{q}_{4G} - 0.1$, max = $\bar{q}_{4G,Int'l,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2013Q1}$ for $t < 2013Q1$ (before 4G handsets were sold in India)
- Indian 4G – expanding potential products over time
  - min = $\underline{q}_{4G} - 0.1$, max = $\bar{q}_{4G,Indian,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2015Q2}$ for $t < 2015Q2$ (before Indian 4G handsets were sold)
- Exogenous and fixed:
  - Apple handsets
  - JioPhone handsets

Definition of Potential Products (Cont.)

- Int'l 3G – same potential products over time
  - $\min = \underline{q}_{3G} - 0.1$, $\max = \bar{q}_{3G,Int'l} + 0.1$
  - Empty from 2017Q2 on (one quarter after Int'l firms stopped selling 3G handsets in India)
- Indian 3G – expanding potential products over time
  - $\min = \underline{q}_{3G} - 0.1$, $\max = \bar{q}_{3G,Indian,t} + 0.1$
- Int'l 4G – expanding potential products over time
  - $\min = \underline{q}_{4G} - 0.1$, $\max = \bar{q}_{4G,Int'l,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2013Q1}$ for $t < 2013Q1$ (before 4G handsets were sold in India)
- Indian 4G – expanding potential products over time
  - $\min = \underline{q}_{4G} - 0.1$, $\max = \bar{q}_{4G,Indian,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2015Q2}$ for $t < 2015Q2$ (before Indian 4G handsets were sold)
- Exogenous and fixed:
  - Apple handsets
  - JioPhone handsets

Definition of Potential Products (Cont.)

- Int'l 3G – same potential products over time
  - min = $\underline{q}_{3G} - 0.1$, max = $\bar{q}_{3G,Int'l} + 0.1$
  - Empty from 2017Q2 on (one quarter after Int'l firms stopped selling 3G handsets in India)
- Indian 3G – expanding potential products over time
  - min = $\underline{q}_{3G} - 0.1$, max = $\bar{q}_{3G,Indian,t} + 0.1$
- Int'l 4G – expanding potential products over time
  - min = $\underline{q}_{4G} - 0.1$, max = $\bar{q}_{4G,Int'l,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2013Q1}$ for $t < 2013Q1$ (before 4G handsets were sold in India)
- Indian 4G – expanding potential products over time
  - min = $\underline{q}_{4G} - 0.1$, max = $\bar{q}_{4G,Indian,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2015Q2}$ for $t < 2015Q2$ (before Indian 4G handsets were sold)
- Exogenous and fixed:
  - Apple handsets
  - JioPhone handsets

Definition of Potential Products (Cont.)

- Int'l 3G – same potential products over time
  - min = $\underline{q}_{3G} - 0.1$, max = $\bar{q}_{3G,Int'l} + 0.1$
  - Empty from 2017Q2 on (one quarter after Int'l firms stopped selling 3G handsets in India)
- Indian 3G – expanding potential products over time
  - min = $\underline{q}_{3G} - 0.1$, max = $\bar{q}_{3G,Indian,t} + 0.1$
- Int'l 4G – expanding potential products over time
  - min = $\underline{q}_{4G} - 0.1$, max = $\bar{q}_{4G,Int'l,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2013Q1}$ for $t < 2013Q1$ (before 4G handsets were sold in India)
- Indian 4G – expanding potential products over time
  - min = $\underline{q}_{4G} - 0.1$, max = $\bar{q}_{4G,Indian,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2015Q2}$ for $t < 2015Q2$ (before Indian 4G handsets were sold)

- Exogenous and fixed:
  - Apple handsets
  - JioPhone handsets

Definition of Potential Products (Cont.)

- Int'l 3G – same potential products over time
  - min = $\underline{q}_{3G} - 0.1$, max = $\bar{q}_{3G,Int'l} + 0.1$
  - Empty from 2017Q2 on (one quarter after Int'l firms stopped selling 3G handsets in India)
- Indian 3G – expanding potential products over time
  - min = $\underline{q}_{3G} - 0.1$, max = $\bar{q}_{3G,Indian,t} + 0.1$
- Int'l 4G – expanding potential products over time
  - min = $\underline{q}_{4G} - 0.1$, max = $\bar{q}_{4G,Int'l,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2013Q1}$ for $t < 2013Q1$ (before 4G handsets were sold in India)
- Indian 4G – expanding potential products over time
  - min = $\underline{q}_{4G} - 0.1$, max = $\bar{q}_{4G,Indian,t} + 0.1$
  - (potential product set)$_t$ = (potential product set)$_{2015Q2}$ for $t < 2015Q2$ (before Indian 4G handsets were sold)

- Exogenous and fixed:
  - Apple handsets
  - JioPhone handsets

Details on Estimating the Dynamic Network Expansion Game

- 12 regions (66.8% of the total population): all 3 Metro regions, all 5 Category-A regions, and the 4 largest Category-B regions Delhi, Kolkata, Mumbai (Metro), Andhra Pradesh & Telangana, Gujarat & Daman & Diu, Karnataka, Maharashtra & Goa, Tamil Nadu (A), Madhya Pradesh & Chhattisgarh, Rajasthan, Uttar Pradesh East, and West Bengal (B)
- Restrictions on action space – consistent with the observed data
  - metro regions before other region categories
  - category-A or Category-B regions only after all Metro regions have at least one carrier
  - category-B regions only after all Metro regions and all Category-A regions have at least one carrier
  - no more than two Metro regions simultaneously, no more than three Category-A regions simultaneously, and no more than three Category-B regions simultaneously

Deal with the Large State Space

- Large action space:
  - state variables: $\mathcal{R}_t = (\mathcal{R}_{1t}, ..., \mathcal{R}_{4t})$ and $\mathcal{R}_{ct}$ is a subset of 12 regions
  - there are $(2^{12})^3 \times 2$ possible values for $\mathcal{R}_t$
- Solution: following Sweeting (2013)
  - compute the value function on a subset of possible state variable values
  - approximate the value function at other state variable values with a linear function of some summary statistics of the state variables
  - lower-dimensional statistics: total market size of the category-g regions that carrier c has entered with its 4G network
    $s_t(\mathcal{R}_t) = \{(M_{1gt}(\mathcal{R}_{1t}), M_{2gt}(\mathcal{R}_{2t}), M_{3gt}(\mathcal{R}_{3t}), M_{4gt}(\mathcal{R}_t)\}_{g=1}^{g=3}$

Estimation Results: Marginal Cost

	Est.	Std. Error
$\mathbb{1}$(Indian) (γ_1)	-1.31***	0.23
Quality (τ_0)	0.10***	0.02
Quality$\times\mathbb{1}$(Indian) (τ_1)	0.16**	0.07
Time Trend $\times\mathbb{1}$(Indian)	-0.05***	0.01
Time Trend $\times\mathbb{1}$(International)	-0.04***	0.01
Jio First Year FE	Yes	

Estimation Results: Marginal Cost

	Est.	Std. Error
$\mathbb{1}$(Indian) (γ_1)	-1.31***	0.23
Quality (τ_0)	0.10***	0.02
Quality$\times\mathbb{1}$(Indian) (τ_1)	0.16**	0.07
Time Trend $\times\mathbb{1}$(Indian)	-0.05***	0.01
Time Trend $\times\mathbb{1}$(International)	-0.04***	0.01
Jio First Year FE	Yes	

Domestic cost advantage at producing low-quality handsets

Estimation Results: Marginal Cost

	Est.	Std. Error
$\mathbb{1}$(Indian) (γ_1)	-1.31***	0.23
Quality (τ_0)	0.10***	0.02
Quality$\times\mathbb{1}$(Indian) (τ_1)	0.16**	0.07
Time Trend $\times\mathbb{1}$(Indian)	-0.05***	0.01
Time Trend $\times\mathbb{1}$(International)	-0.04***	0.01
Jio First Year FE	Yes	

Domestic cost advantage at producing low-quality handsets

But Indian firms' mc increase at a faster speed with quality

Estimation Results: Marginal Cost

	Est.	Std. Error
$\mathbb{1}$(Indian) (γ_1)	-1.31***	0.23
Quality (τ_0)	0.10***	0.02
Quality$\times\mathbb{1}$(Indian) (τ_1)	0.16**	0.07
Time Trend $\times\mathbb{1}$(Indian)	-0.05***	0.01
Time Trend $\times\mathbb{1}$(International)	-0.04***	0.01
Jio First Year FE	Yes	

MC of producing handsets decreases over time

Estimation Results: Fixed Cost

- For $j \in \mathcal{J}_{ft}^{(h)}$: $C_{jt} \leq \pi_{ft}^{(h)}(\mathcal{J}_{ft}^{(h)}, \mathcal{J}_{-ft}^{(h)}, ...) - \pi_{ft}^{(h)}(\mathcal{J}_{ft}^{(h)} \setminus j, \mathcal{J}_{-ft}^{(h)}, ...)$

  For $j \notin \mathcal{J}_{ft}^{(h)}$: $C_{jt} \geq \pi_{ft}^{(h)}(\mathcal{J}_{ft}^{(h)} \cup j, \mathcal{J}_{-ft}^{(h)}, ...) - \pi_{ft}^{(h)}(\mathcal{J}_{ft}^{(h)}, \mathcal{J}_{-ft}^{(h)}, ...)$

- FC: $C_{jt} = 0.8C_{jt}^{U}$ for $j \in \mathcal{J}_{t}^{(h)}$, $C_{jt} = 1.2C_{jt}^{L}$ for $j \notin \mathcal{J}_{t}^{(h)}$
- Finding: cost advantages of int'l handset firms:

Median 4G Handset Fixed Cost (Million INR)

Origin	Low-Quality	Low-Medium	High-Medium	High-Quality
Indian	983	1458	-	-
International	544	1353	5003	5984

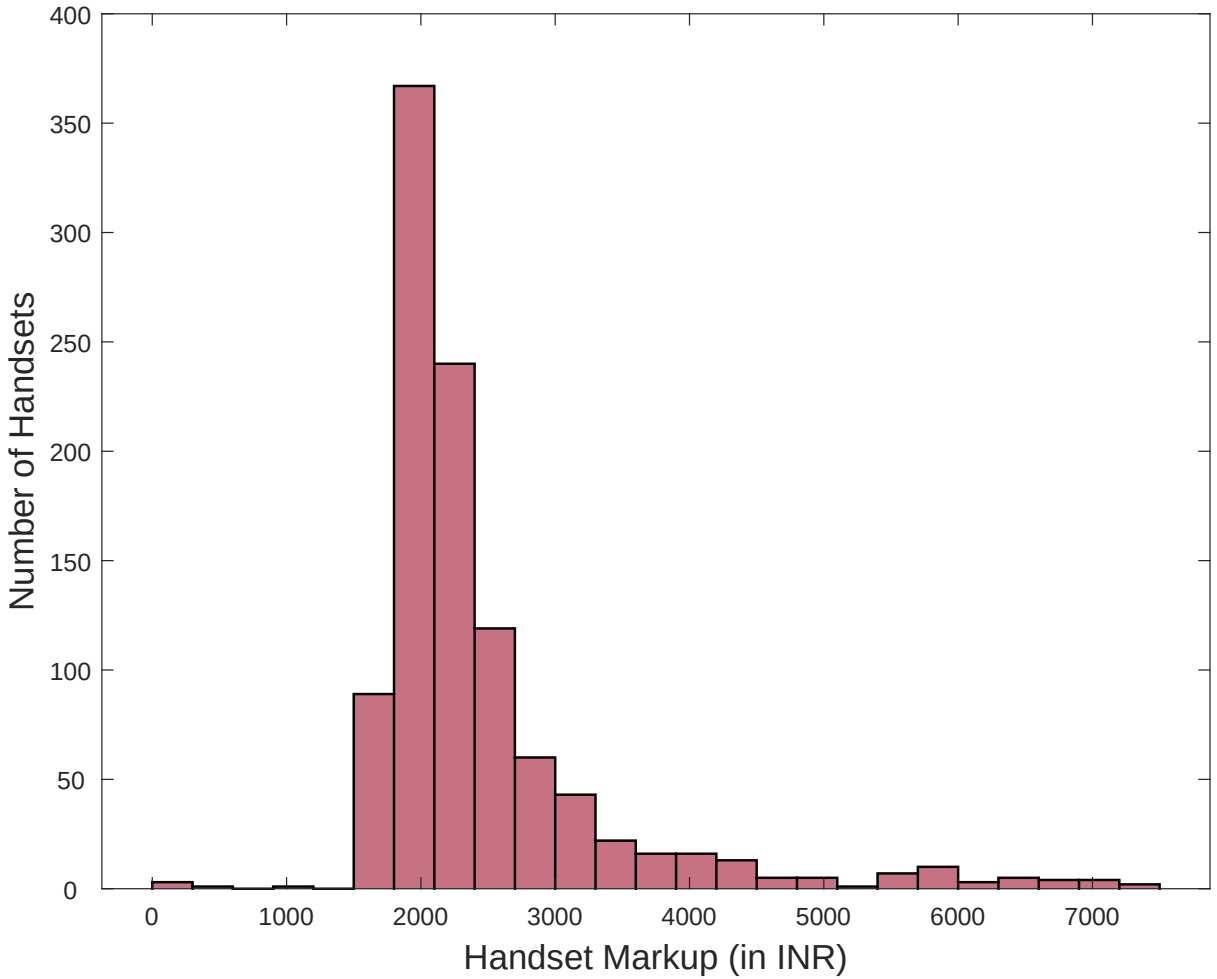
Estimation Results: Fixed Cost

- For $j \in \mathcal{J}_{ft}^{(h)}$: $C_{jt} \leq \pi_{ft}^{(h)}(\mathcal{J}_{ft}^{(h)}, \mathcal{J}_{-ft}^{(h)}, ...) - \pi_{ft}^{(h)}(\mathcal{J}_{ft}^{(h)} \setminus j, \mathcal{J}_{-ft}^{(h)}, ...)$
  For $j \notin \mathcal{J}_{ft}^{(h)}$: $C_{jt} \geq \pi_{ft}^{(h)}(\mathcal{J}_{ft}^{(h)} \cup j, \mathcal{J}_{-ft}^{(h)}, ...) - \pi_{ft}^{(h)}(\mathcal{J}_{ft}^{(h)}, \mathcal{J}_{-ft}^{(h)}, ...)$
- FC: $C_{jt} = 0.8C_{jt}^{U}$ for $j \in \mathcal{J}_{t}^{(h)}$, $C_{jt} = 1.2C_{jt}^{L}$ for $j \notin \mathcal{J}_{t}^{(h)}$
- Finding: cost advantages of int'l handset firms:

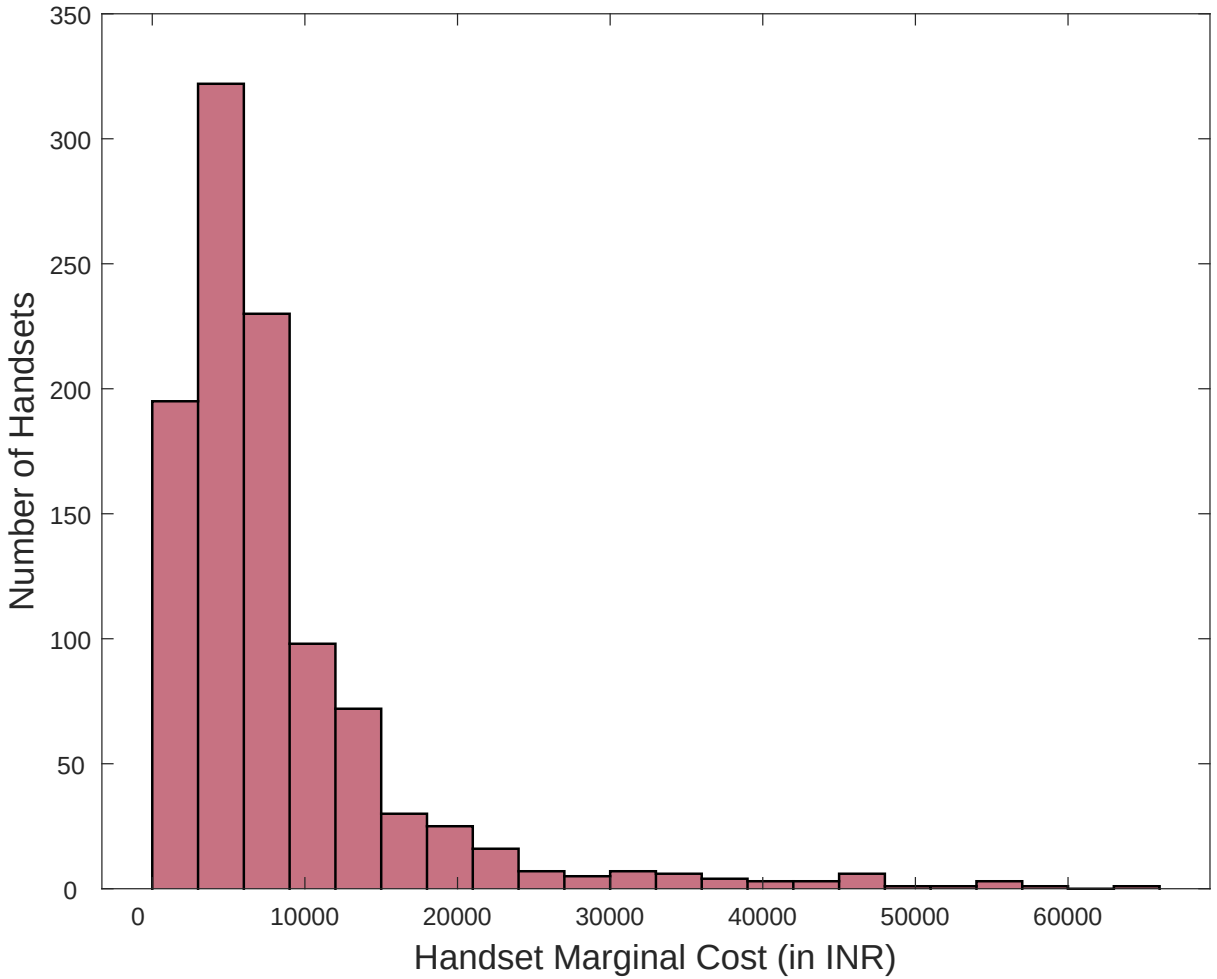
Median 4G Handset Fixed Cost (Million INR)

Origin	Low-Quality	Low-Medium	High-Medium	High-Quality
Indian	983	1458	-	-
International	544	1353	5003	5984

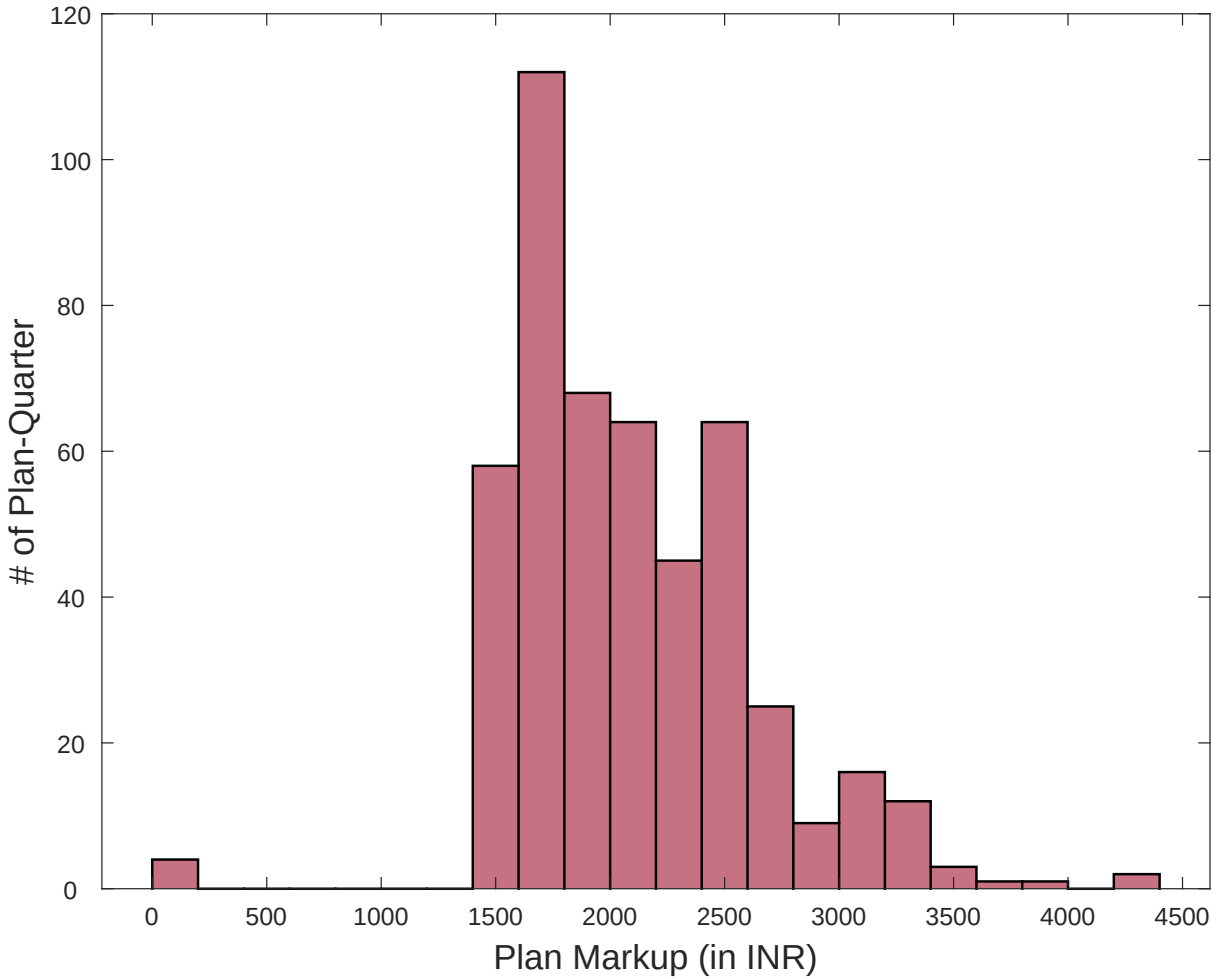
Handset Markups



Handset Marginal Costs



Plan Markups



4G Plan Markups