Awarding Spectrum with a Focus on Improved Mobile Services
Research and Proposed Best Practice

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Agenda

- Background
- Research approach
- Results and findings
- Best practice
- The future – coverage and verticals
Spectrum prices vary – some are very high

Spectrum prices in 102 countries, 2010-2017

Source: GSMA Intelligence. Spectrum prices ($/MHz/pop/year) have been adjusted by inflation, PPP (2016 prices) and licence duration, and aggregated by country, band, generation and assignment. The IQR is defined as the observations between the 1st and 3rd quartile. Outliers are classified as being above an "inner fence", i.e. above 3rd quartile + 1.5*IQR. Extreme outliers are classified as being above an "outer fence", i.e. above 3rd quartile + 3*IQR.
Prices much higher in developing countries

After taking into account for differences in income (i.e. $/MHz/GDP)

GSMAi study also found a link between high prices and short-term sovereign debt

GSMAi: Study of over 1000 awards of spectrum bands across 102 countries from 2010-2017 (published 2018)
### High reserves leading to award failures

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mozambique</td>
<td>2013</td>
<td>800 MHz</td>
</tr>
<tr>
<td>Australia</td>
<td>2013</td>
<td>700 MHz</td>
</tr>
<tr>
<td>Senegal</td>
<td>2016</td>
<td>800 MHz</td>
</tr>
<tr>
<td>India</td>
<td>2016</td>
<td>700 MHz</td>
</tr>
<tr>
<td>South Korea</td>
<td>2016</td>
<td>700 MHz</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>2018</td>
<td>900/1800/2100MHz</td>
</tr>
<tr>
<td>Mozambique</td>
<td>2018</td>
<td>1800/2600 MHz</td>
</tr>
<tr>
<td>Ghana</td>
<td>2018</td>
<td>800 MHz</td>
</tr>
<tr>
<td>Thailand</td>
<td>2019</td>
<td>700 MHz</td>
</tr>
</tbody>
</table>
What drives higher spectrum prices?

- Demand and willingness to pay (market factors)
- But also spectrum policy...
  - Very high (reserve) prices and/or fees
  - Limited supply of spectrum
  - Not publishing a spectrum roadmap
  - Award design (auction format, lot size/number etc)

SINGLE SELLER OF SPECTRUM (GOVERNMENT) HAS MARKET POWER
Can spectrum prices impact consumers?

Does spectrum represent a sunk cost?

- Once incurred, spectrum fees cannot be recovered (especially upfront costs)
- Costs therefore not taken into account in subsequent decisions around network investment & consumer pricing
- Some governments have used this argument to push back against criticism of very high auction returns

Or does it impact investment & pricing?

- Operators have to recover fixed costs to deliver sufficient returns to investors/lenders
- Spectrum assignments directly impact forward-looking costs and revenues (and therefore commercial strategies)
- Intrinsic difficulty in predicting future developments in the mobile market

THEORY IS UNCLEAR SO WE ARE LEFT WITH AN EMPIRICAL QUESTION
Study by GSMA to address evidence gaps

- New study assessing the impact of spectrum prices on three broad consumer outcomes:
  1. Network coverage
  2. Network quality (data speeds & latency)
  3. Consumer prices

- Analyse 229 operators in 64 countries (34 high income and 30 low & middle income) from 2010-2017

- Most comprehensive study conducted on this topic to date. Previous in-depth studies have only looked at consumer prices and mostly developed countries
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Econometric analysis considers how spectrum prices impact consumer outcomes *after isolating other confounding factors* (from correlation to a causal link).

<table>
<thead>
<tr>
<th>Methodology Details</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country fixed-effects</td>
<td>Controls for country-specific factors such as geography</td>
</tr>
<tr>
<td>Time fixed-effects</td>
<td>Controls for time-specific factors such as new technologies and handsets</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>Proxy for average income (affects prices &amp; adoption of new technologies)</td>
</tr>
<tr>
<td>Population distribution</td>
<td>Population density and % rural population (affects network costs &amp; quality)</td>
</tr>
<tr>
<td>Market concentration</td>
<td>HHI used as proxy for market structure and the extent of competition</td>
</tr>
<tr>
<td>Smartphone adoption</td>
<td>Smartphone users likely to adopt new technologies and have digital skills</td>
</tr>
<tr>
<td>Operator scale</td>
<td>Market share used as a proxy for the scale of an operator</td>
</tr>
<tr>
<td>Spectrum holdings</td>
<td>The amount of spectrum impacts network quality and investments</td>
</tr>
<tr>
<td>Spectrum timings</td>
<td>Indicator to capturing the time that operators have had relevant spectrum</td>
</tr>
<tr>
<td>Licence obligations</td>
<td>Indicator to capture if operator has coverage or QoS obligations</td>
</tr>
</tbody>
</table>

Source: GSMA Intelligence (2019)
Dealing with two-way causality

- High spectrum prices can lead to higher consumer prices
- BUT the expectation of high consumer prices can drive higher spectrum prices. The same logic applies to network coverage and quality.
- Two-fold empirical strategy to deal with this issue:
  - **Use relative instead of absolute spectrum price levels**: Spectrum prices as a % of annual revenue per licenced year (considering current and future revenues)
  - **Instrumental variable regression**: identification of one or more indicators that impact the price of spectrum but not the consumer outcomes: (i) short-term government debt; (ii) assignment method (auction vs non-auction), and; (iii) final and reserve prices in region
Evolution of different spectrum prices

**Unit cost of spectrum per person** gives an indication of spectrum costs to serve a potential customer base.

**Spectrum cost as a proportion of revenues** gives an indication of the returns of spectrum as an investment.

Source: GSMA Intelligence. Spectrum prices have been adjusted by inflation, PPP (2016 prices) and licence duration, and aggregated by country, band, generation and assignment. The analysis is based on three-year moving averages.
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## Impact of higher spectrum prices

<table>
<thead>
<tr>
<th></th>
<th>Developing Countries</th>
<th>Developed Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network Coverage</strong></td>
<td>Slower deployment of 4G and 3G networks</td>
<td>Slower deployment of 4G networks</td>
</tr>
<tr>
<td><strong>Network Quality</strong></td>
<td>Poorer network quality (overall and for 3G)</td>
<td>Slower 4G download speeds</td>
</tr>
<tr>
<td><strong>Consumer Prices</strong></td>
<td>Some evidence of higher prices but not conclusive</td>
<td>Inconclusive – better data needed</td>
</tr>
</tbody>
</table>

Source: GSMA Intelligence (2019)
## Impact of other spectrum policies

<table>
<thead>
<tr>
<th>Network Coverage</th>
<th>All countries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>More licensed spectrum drives higher coverage</strong>&lt;br&gt;• Additional 20 MHz increases 4G coverage by 2-4 percentage points</td>
<td><strong>Early spectrum release drives higher coverage</strong>&lt;br&gt;• Assigning spectrum at least two years earlier increases 4G coverage by 11-16 percentage points and 3G coverage by 20 percentage points (all else equal)</td>
</tr>
<tr>
<td><strong>Network Quality</strong></td>
<td><strong>More licensed spectrum drives higher network quality</strong>&lt;br&gt;• Additional 20 MHz of 4G spectrum increases average download speeds by 1-2.5 Mbps</td>
</tr>
</tbody>
</table>

Source: GSMA Intelligence (2019)
Pricing simulation analysis for 4G coverage

- 4G coverage for operators that paid high prices (above inner fence)

- Compare actual coverage with simulated coverage if spectrum prices had been in line with global median

- Operators would have achieved 7.5 percentage points higher coverage by the end of 2017

Source: GSMA Intelligence. Covers 17 operators that experienced significant price outliers over this period, operating in Thailand, Jamaica, Austria, Pakistan, Jordan, Venezuela, Israel, Kenya, Moldova, Colombia and Costa Rica.
Spectrum holdings impact network quality

- Amount of spectrum impacts network quality
- Compare actual with simulated download speeds if more spectrum released to operators with 20 MHz less than median
- Speeds would have been 2.5Mbps faster (15% increase) over the period if spectrum holdings had been at average levels

Source: GSMA Intelligence. Covers 10 operators that had 20 MHz less than the median level for both 3G and 4G spectrum holdings, operating in Ukraine, Colombia, Pakistan, Brazil and Taiwan.
## Conclusions

1. High spectrum prices slowed the roll-out of next-generation networks in developed and developing markets in 2010-17

2. More expensive spectrum reduced network quality in both developed and developing markets

3. Higher spectrum prices are associated with higher consumer prices in developing countries, but further research is needed

4. Early release of spectrum and sufficient amounts of licenced spectrum are important drivers of consumer welfare
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How do the findings translate to best practice?

- Three key findings for supporting consumer benefits
  - High spectrum prices harm network coverage & quality
  - More spectrum in the market helps network quality & coverage
  - Early awards have a major impact on coverage

- Equate to two key risks when planning awards
  - Avoid inflating prices
  - Avoid spectrum scarcity
Auction mistakes: Artificially inflating prices

- Setting high reserve prices and annual fees
  - Undermines role of auction to discover the market price
  - Can lead to unsold spectrum which wastes a valuable asset
- Auction designs that create unnecessary risks
  - No price discovery (e.g. Single round, sealed bids)
- Limiting spectrum supply…
Auction mistakes: Artificial spectrum scarcity

- Not assigning enough spectrum
  - Forced to overbid for desperately needed spectrum
- Reserving spectrum for new entrants/verticals
- Not creating and updating a spectrum roadmap
- Poorly chosen lot sizes or inflexible packages
  - Mismatched or overly large lot sizes can create scarcity
  - Inability to swap bids means operators can end up with the wrong spectrum
Five key things to remember

1. Prioritise consumers and the wider digital economy ahead of maximising auction revenues (high price ≠ success)
2. Auctions are proven but can fail when poorly designed – especially factors which inflate prices and constrain supply
3. Auctions are not always suitable (e.g. for renewals)
4. Carefully consider licence obligations – they impact award and consumer outcomes (more on this next!)
5. Consult stakeholders to enable timely & fair awards
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- Two future risks/opportunities – coverage and verticals
Spectrum for verticals – constraining supply?

Setting aside 5G spectrum for verticals could jeopardise consumer 5G benefits

- **Some countries have set-aside spectrum for verticals leading to higher price auctions**
  - German set-aside for verticals in the 3.5 GHz band led to claims it inflated auction prices
  - Sweden set-aside for the public safety network in 700 MHz (auction prices almost double 800 MHz award)

- **Operators have concerns a vertical set-asides may harm public 5G networks**
  - Limits amount of spectrum available for 5G which reduces network performance
  - Risks inflating spectrum prices leading to reduced coverage and network quality

- **Other countries are using alternatives to dedicated set-asides**
  - Finland but assigned all spectrum by auction but added sub-leasing clause in licences to support verticals
  - The US CBRS approach supports any kind of local network – so set-aside not just for verticals
  - UK is assigning all of 3.4-3.8 GHz by auction band but then looking at local licensing in 3.8-4.2 GHz
Using spectrum pricing to improve coverage

- **Swedish MNOs claim back part of their auction bid to pay for rural base stations**
  - Regulator provided list of post codes to be covered by one 700 MHz and 800 MHz licence
  - Applicants could count $22m-$44m of rural network investment in their bid

- **French MNOs investing €3bn to improve coverage in exchange for low cost renewal**
  - Decision to forgo auction of 900/1800/2100 MHz & discounted annual fees for 10yr licences
  - 5,000 new areas must get 4G coverage – identified by government/local authorities

- **UK MNOs propose “Single Rural Network” through joint private and public funds**
  - New jointly-owned company to build 4G network in areas where no MNOs provide coverage today
  - Aim to eliminate notspots with £1bn funding from MNOs and government (through spectrum fees)
Just to be clear on spectrum pricing & awards..

We are NOT saying…
- Auctions are a bad award mechanism ☒
- “High” spectrum prices are always bad ☒
- Raising state revenues through auctions is bad ☒

We ARE saying…
- Policies that distort market-based spectrum pricing harm consumers ☑
- The right spectrum price is never more than the true market value ☑
- Fair spectrum prices are essential for a healthy broadband future ☑
For more information please contact:
ochapman@gsma.com

And visit:
www.gsma.com/spectrum/resources/efficient-spectrum-pricing/
https://www.gsma.com/spectrum/resources/spectrum-auctions/