The profitability analysis of the multi-band spectrum broker

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Spectrum crunch

Wireless data growth leads to spectrum deficit

Traffic growth per cell site

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth</td>
<td>100%</td>
<td>197%</td>
<td>268%</td>
<td>612%</td>
<td>925%</td>
<td>1250%</td>
</tr>
</tbody>
</table>

400 MHz

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHz</td>
<td>377</td>
<td>322</td>
<td>225</td>
<td>87</td>
<td>-90</td>
<td>-275</td>
</tr>
</tbody>
</table>

Source: FCC
New licensing scheme

- Operators need an additional spectrum resources for LTE/LTE-A services
  - Capacity extension scenario
- They can buy spectrum via broker services (coordinated spectrum access)
- Spectrum trading for capacity extension to the existing users
Spectrum resources – licenses

- 5 / 10/ 20 MHz LTE channels dependent on the frequency bands and the available spectrum resources
- 1 spectrum license – single frequency channel for 1 day in single location
- Short license time brings more flexibility to the market.
- Broker must use the proper protection criteria to avoid interference between players having licenses for the same frequency channels in different locations.

<table>
<thead>
<tr>
<th>Band</th>
<th>Channel size and transmit power</th>
<th>Number of licenses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Full FDD</strong></td>
</tr>
<tr>
<td>TVWS</td>
<td>5 MHz / 25 or 30 dBm</td>
<td>-</td>
</tr>
<tr>
<td>GSM 900</td>
<td>10 MHz / 46 dBm</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>10 MHz/ 46 dbm</td>
<td>-</td>
</tr>
<tr>
<td>GSM 1800</td>
<td>20 MHz / 46 dBm</td>
<td>5</td>
</tr>
<tr>
<td>NTIA 1800</td>
<td>20 MHz / 46 dBm</td>
<td>-</td>
</tr>
<tr>
<td>2500 MHz</td>
<td>20 MHz/ 46 dBm</td>
<td>5</td>
</tr>
</tbody>
</table>
Spectrum pricing - methodology

\[ PoS = p \cdot l \cdot d \cdot S \cdot O \cdot x \]

- The formula express the most important market factors which may influence into the price of 1 MHz:
  - \( p \) – the benchmark price for the sold spectrum (based on spectrum auctions in neighboring frequency bands)
  - \( l \) – license period
  - \( d \) – the population density per square kilometer
  - \( S \) – the allocation area
  - \( O \) – the operators market share factor
  - \( x \) - the incentives of operators in rural / suburban / urban areas.

- Not used but still may be considered:
  - \( t \) – the allocation time (morning / afternoon / evening / night)
  - inflation after spectrum auction
Spectrum pricing – examples

• Benchmark prices:
  • $p = 0.72286 \, \text{€/MHz/pop}$ taken from German LTE spectrum auction in 800 MHz band used for TVWS and GSM 900 bands,
  • $p = 0.02535 \, \text{€/MHz/pop}$ taken from German LTE spectrum auction in 1800 MHz band used for L, GSM 1800, and NTIA 1800 bands,
  • $p = 0.02231 \, \text{€/MHz/pop}$ taken from German LTE spectrum auction in 2600 MHz band used for 2500 MHz band,
• $l = \frac{1}{3650}$ for one day licenses (compared with 10 years allocation time in German LTE auction)
• $d = 230 \, \text{km}^2$ – population density for Germany
• $S = 3.14 \, \text{km}^2$ for 1 km cell radius
• $O = 0.25$ because of four operators in Germany (O2, T-Mobile, Vodafone and E-Plus),
• $x = 5 / 10 / 20$ for rural / suburban and urban areas
## Spectrum pricing – examples

The *PoS* for different bands (€/MHz/Day)

<table>
<thead>
<tr>
<th>Area type</th>
<th>Band</th>
<th>TVWS/GSM 900</th>
<th>L / GSM 1800/ NTIA 1800</th>
<th>2500 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td></td>
<td>0.179</td>
<td>0.006</td>
<td>0.0055</td>
</tr>
<tr>
<td>Suburban</td>
<td></td>
<td>0.358</td>
<td>0.012</td>
<td>0.0110</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
<td>0.716</td>
<td>0.025</td>
<td>0.0220</td>
</tr>
</tbody>
</table>
Deployment boundaries

• Spectrum demands will come mainly from urban areas!
  • Small allocation areas – trading pixels (0.2 km x 0.2 km)
  • The allocated channel is blocked in neighbour pixels.

• Munich (urban part: 310km²)
  • For 1 km radius there are 400 base station needed to provide the full coverage (by single operator)
  • In paper we shown that 100 licenses (5 MHz channels) may be used to provide the additional supply in TVWS frequency band.
  • In other bands (L band) there can be used 400 licenses.

• Germany
  • 10000 licenses in TVWS frequency band
  • 40000 licenses in L band
Profitability analysis - incomes

\[ \Pi_{\text{year}} = B \cdot PoS \cdot N_{\text{BS}} \cdot T \]

- The broker’s incomes are based on:
  - \( B \) – the channel size,
  - \( PoS \) – the average price of spectrum,
  - \( N_{\text{BS}} \) – the number of deployed base stations (sold licenses)
  - \( T \) – the number of days.
- Incomes for TVWS and 5 MHz channels (M€):

<table>
<thead>
<tr>
<th>No of BS</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1k BS</td>
<td>0.365</td>
<td>0.73</td>
<td>1.095</td>
<td>1.46</td>
<td>1.825</td>
</tr>
<tr>
<td>2.5k BS</td>
<td>0.9125</td>
<td>1.825</td>
<td>2.7375</td>
<td>3.65</td>
<td>4.5625</td>
</tr>
<tr>
<td>5k BS</td>
<td>1.825</td>
<td>3.65</td>
<td>5.475</td>
<td>7.3</td>
<td>9.125</td>
</tr>
<tr>
<td>10k BS</td>
<td>3.65</td>
<td>7.3</td>
<td>10.95</td>
<td>14.6</td>
<td>18.25</td>
</tr>
<tr>
<td>20k BS</td>
<td>7.3</td>
<td>14.6</td>
<td>21.9</td>
<td>29.2</td>
<td>36.5</td>
</tr>
</tbody>
</table>
Profitability analysis - incomes

• Incomes for L band and 10 MHz channels (M€):

<table>
<thead>
<tr>
<th>No of BS</th>
<th>0.02</th>
<th>0.04</th>
<th>0.06</th>
<th>0.08</th>
<th>0.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1k BS</td>
<td>0.073</td>
<td>0.146</td>
<td>0.219</td>
<td>0.292</td>
<td>0.365</td>
</tr>
<tr>
<td>2.5k BS</td>
<td>0.1825</td>
<td>0.365</td>
<td>0.5475</td>
<td>0.73</td>
<td>0.9125</td>
</tr>
<tr>
<td>5k BS</td>
<td>0.365</td>
<td>0.73</td>
<td>1.095</td>
<td>1.46</td>
<td>1.825</td>
</tr>
<tr>
<td>10k BS</td>
<td>0.73</td>
<td>1.46</td>
<td>2.19</td>
<td>2.92</td>
<td>3.65</td>
</tr>
<tr>
<td>20k BS</td>
<td>1.46</td>
<td>2.92</td>
<td>4.38</td>
<td>5.84</td>
<td>7.3</td>
</tr>
</tbody>
</table>

• To obtain the incomes for the 900 MHz band you can multiply the results from previous table by 2 (because the channels in GSM 900 band are 2 times wider). To obtain the incomes for 20 MHz channels in GSM 1800 or NTIA 1800 MHz you can multiply the results from this table by 2.

• In all cases we assumed the FDD downlink.
Profitability analysis – costs

- **Assumptions:**
  - WEBID software (GNU General Public License) like in ICT-COGEU demo.
  - fully automated trading process - 2 managers + 4 software engineers.
  - No advertising and marketing costs (link from the regulator’s website).
  - Office space equals 30 m2 and the rent is 25 €/m2 (Munich)

- **CAPEX:**
  - Auction system development – 30000€ (5000€ * 6 man months)
  - Hardware for employees - 8000€,
  - Software for employees – 6000€,
  - Office equipment costs - 2000€,
  - **Total costs: ~46 000 €**

- **OPEX:**
  - Salary to employees with tax - 360000€/year (30000€/month),
  - Office rent - 9000€/year (750€/month),
  - Mobile phone fees - 3600€/year (150€/month),
  - Auction system hosting (business option) and hardware leasing – 500€/year,
  - **Total costs: ~382 100 €**

- **TOTAL COSTS ~400 000 €**
Profitability analysis – conclusions

- **Commissions (if broker is managed by a 3rd party company):**
  - Paid only for sold licenses
  - The total amount of commissions paid to the regulator and to the geo-location database provider should not exceed 50% of its revenue (5-10% to the geo-location database provider and 25-40% to the regulator).
  - Progressive commissions.

- **Conclusions**
  - The market cannot guarantee the stability
  - In such case the broker’s services are profitable for the spectrum price higher than 0.2 €/MHz/day and for 1000 sold licenses or for 0.05 €/MHz/day and 2500 sold licenses. This is the minimum price condition which must be satisfied otherwise the flexible spectrum trading will not be profitable.
  - Broker can be profitable if it sells the frequency resources from many bands.
Acknowledgement

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• And because we are in Rome …