Bootstrap approach to data & spectrum demand estimation

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Context

Motivation

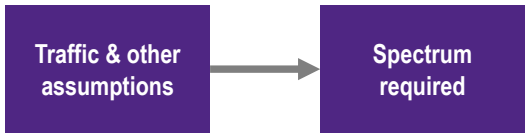
- Mobile data & spectrum demand inputs to
  - Assignment and allocation decisions
  - Spectrum pricing
  - Auction design & bidding
- Traditional approaches generate knife edge results – spectrum surplus or crunch
  - Data demand independent of network capacity and implied data cost-price
  - User willingness to pay not considered
- Bootstrap model embeds supply & demand
  - Helps with understanding
  - Points to different relationships & key assumptions re spectrum value
  - Provides data forecast as by-product

Points to note

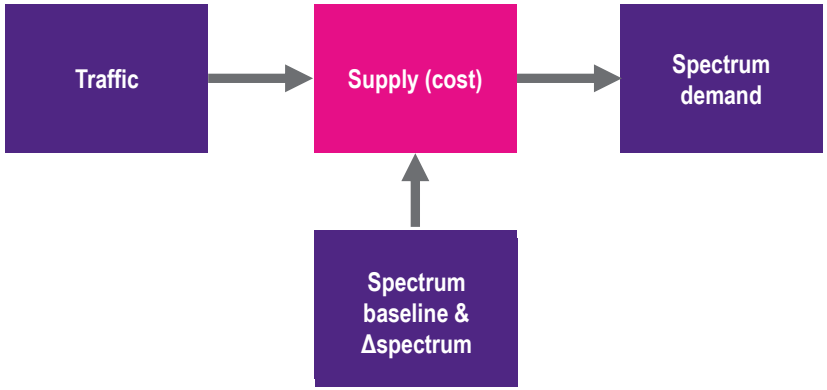
- Spectrum demand (from economic perspective)
  - Not just a quantity
  - Involves quantities & willingness to pay (or implied price)
  - Closer to concept of value
- Spectrum demand
  - Depends on data demand
  - Which depends on quality of service & price of data
- An efficient spectrum allocation would take account of competing demand/s
  - We only consider mobile demand here
- Our modelling focusses on spectrum value for capacity (established network case)

‘Traditional’ approaches (data demand exogenous)

Technical model – no cost function



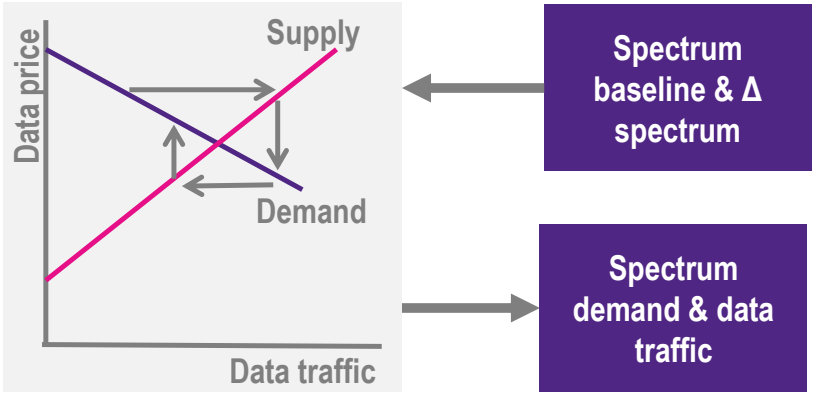
Avoided cost - includes supply side but not economic demand



But network capacity, quality and price will influence data demand…

Bootstrap approach (endogenous data demand)

Solving for supply-demand equilibrium generates spectrum demand & data traffic path



Approach

- Demand side (base case)
  - Individual expenditure in 2030 is assumed equal to start point expenditure
  - Subscriber growth from 60% to 90% of population
- Supply side (base case)
  - Assumptions in Plum Insight paper
- Solve iteratively for data supply-demand equilibrium
- Add spectrum increment to get spectrum demand (avoided cost)
- Repeat for various spectrum base assumptions to generate spectrum demand curve
- Avoided cost model is a special case of bootstrap model (data price elasticity = 0)

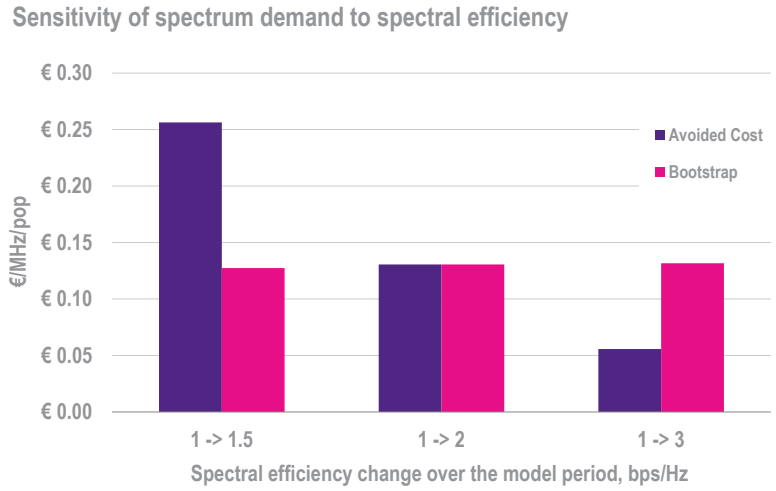
Implications of bootstrap approach

- Data traffic depends on other assumptions – it is not a fixed input assumption
- Operators invest in site capacity only when consumers are willing to pay for it
- Consumer expenditure may be constant or change over time
  - Due to a shift in the demand curve e.g. consumers value mobile data more in the future when there are more useful apps
  - Due to changes in the price of data via the price elasticity of demand
- Data traffic may change under the bootstrap approach in response to changes in input assumptions such as spectrum efficiency, spectrum availability etc.
- May reduce sensitivity of spectrum demand to changes in network capacity i.e. spectrum demand no longer a “knife-edge” phenomenon

Bootstrap approach may allow for greater “realism” – we now consider the character of the model

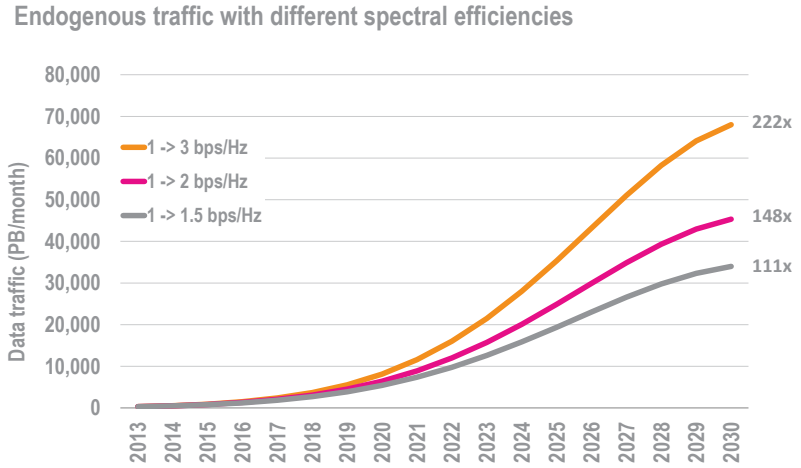
Supply - spectrum efficiency increase

Large difference in sensitivity of avoided cost & bootstrap models



Source: Plum Consulting

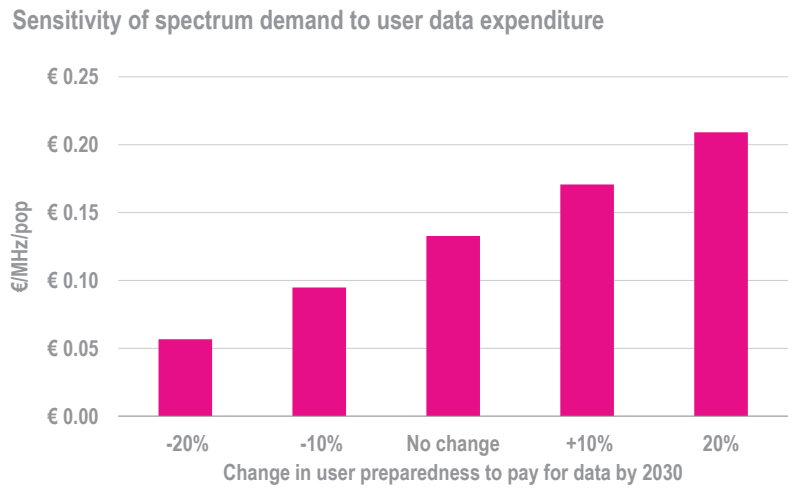
Bootstrap data traffic, rather than spectrum value, changes with efficiency



Source: Plum Consulting

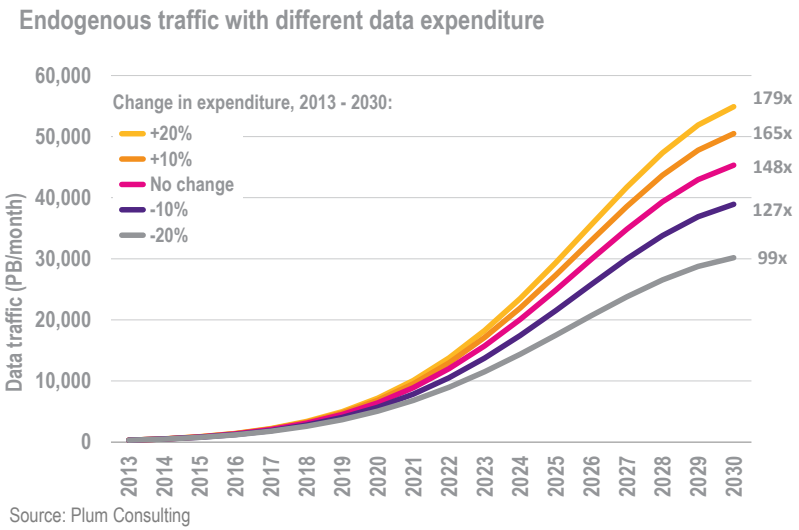
Demand - change in data demand (bootstrap only)

Spectrum demand sensitive to willingness to pay for data



Source: Plum Consulting

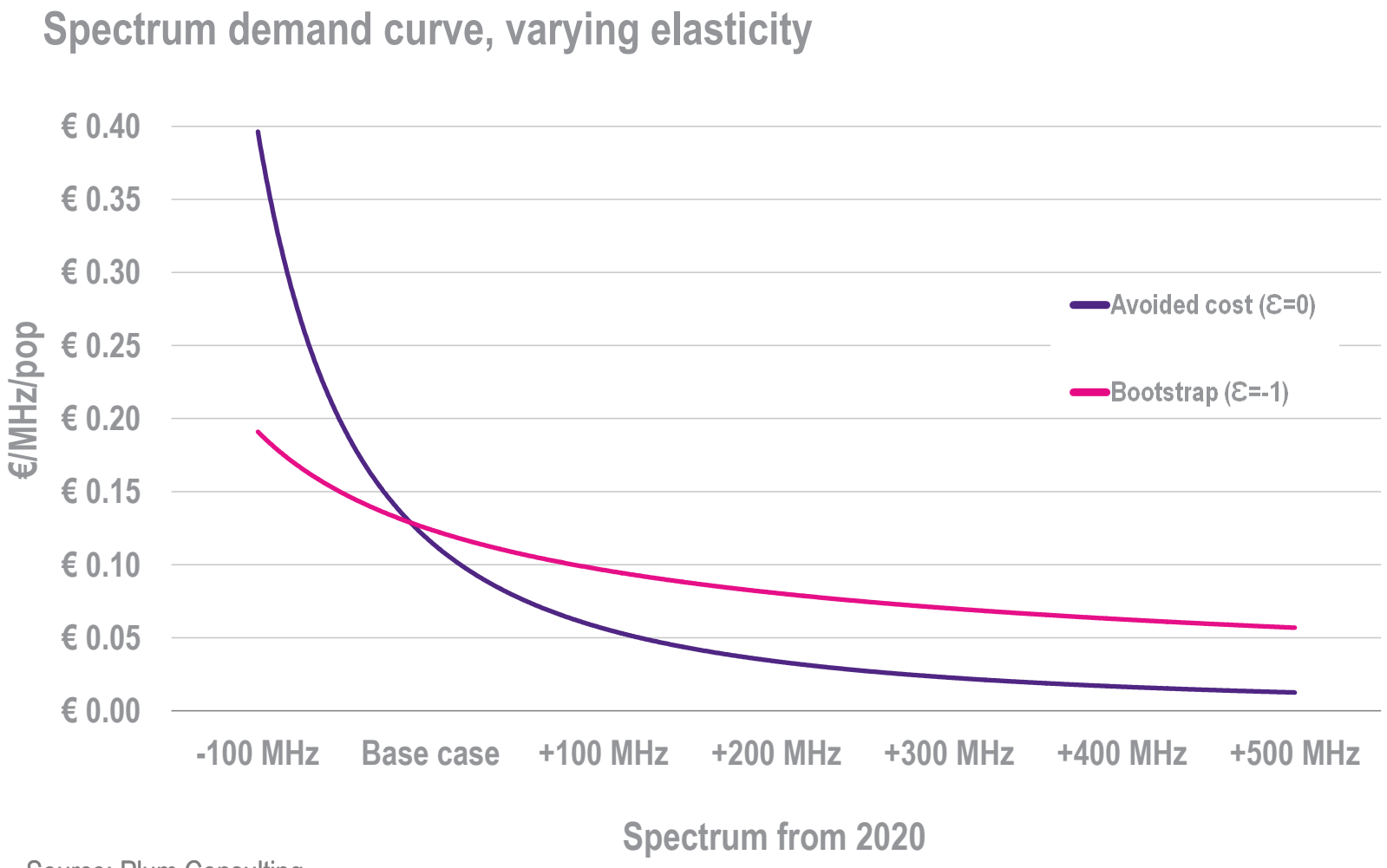
Traffic sensitive to willingness to pay for data



Source: Plum Consulting

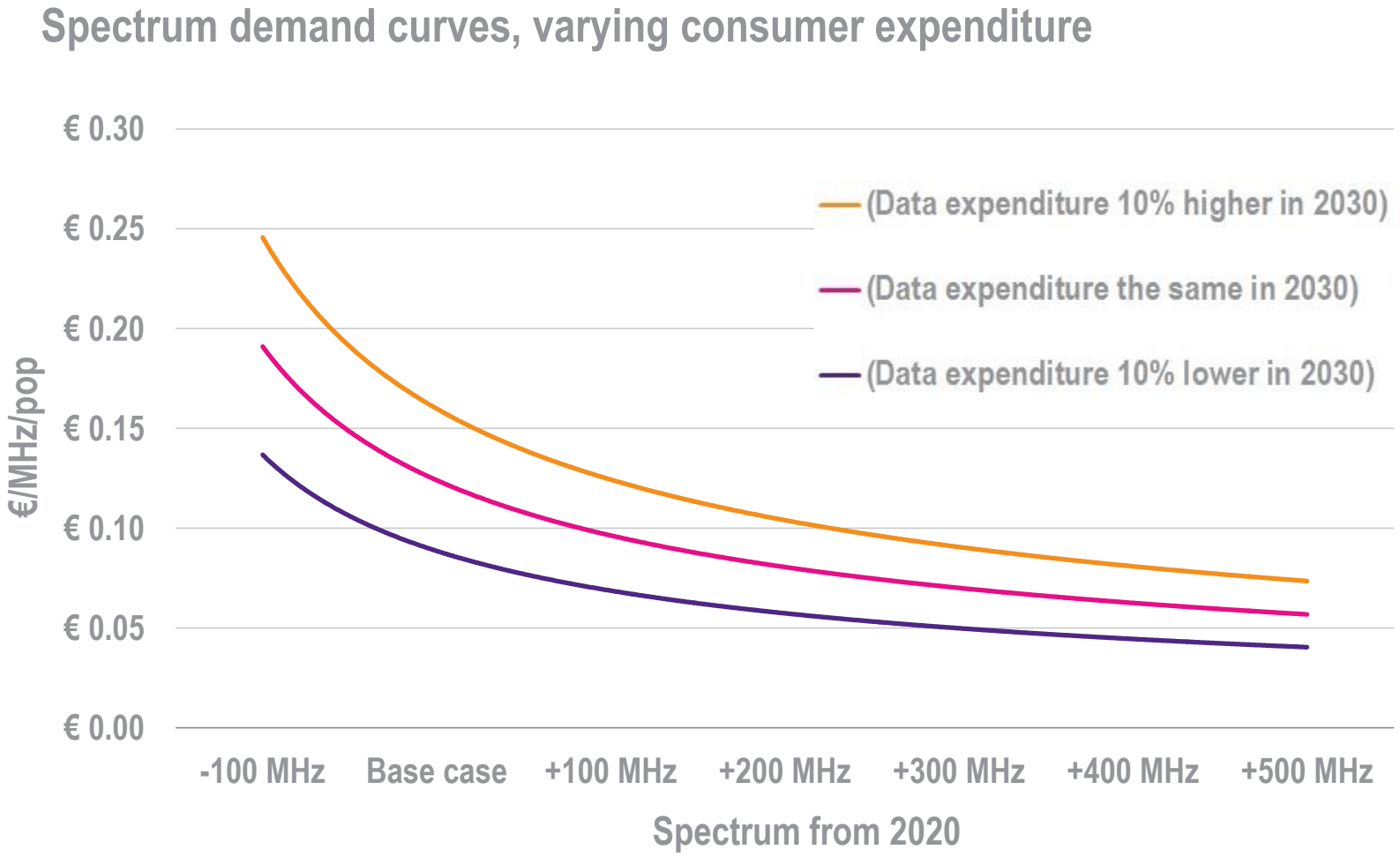
Focus on WTP may be more intuitive (& commercial) than judging appropriate data growth rate

Spectrum demand curve – model/data elasticity



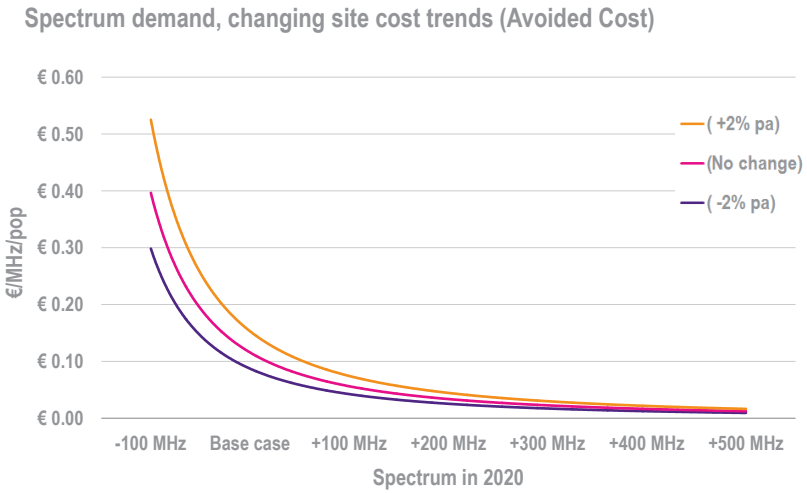
Source: Plum Consulting

Spectrum demand curve – data spend trend



Source: Plum Consulting

Spectrum demand curve – site cost trend



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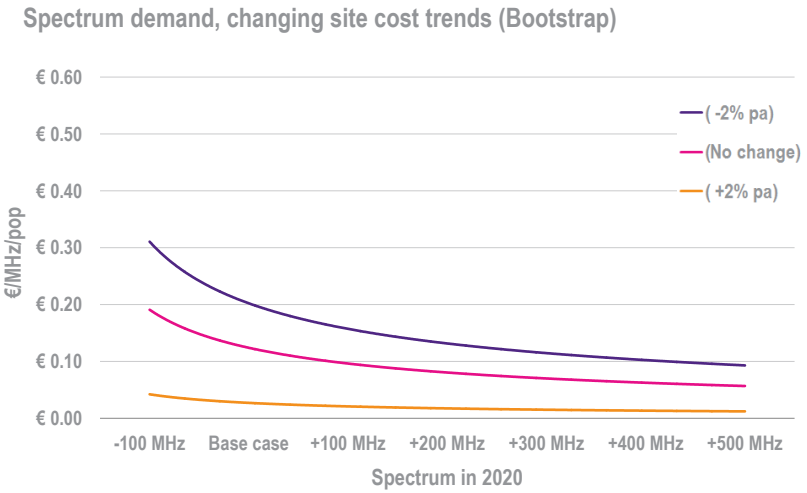

Source: Plum Consulting

Site cost trend important assumption for bootstrap (& direction of impact reverses vs. avoided cost!)

Spectrum demand - summary

	Exogenous (elasticity 0)	Bootstrap (elasticity -1)
Traffic growth forecast	Sensitive (increase)	Not applicable
Wi-Fi 'offload'	Sensitive (decrease)	Not applicable (indirect via willingness to pay)
Site capacity increase over time	Sensitive (decrease)	Insensitive
Site cost decline over time	Insensitive (decrease)	Sensitive (increase)
Willingness to pay increase over time	Not applicable	Sensitive (increase)

Need to consider rates of change of key input variables & strength of feedbacks