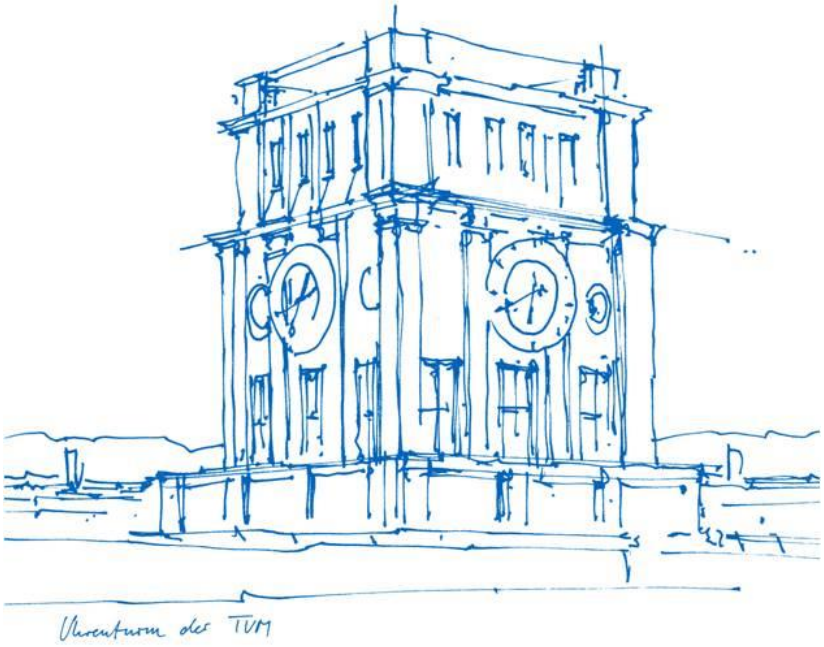
Final presentation – bachelors‘ thesis

Title: A Comparison of the Impact of Auction Formats Used in the 2015 German Spectrum Auction "Mobiles Breitband - Projekt 2016"

Tim Berger

Munich, 15th Sept 2016



Agenda

1. The German Auction in 2015
2. Comparison of the Auction Formats
3. Simulation Set-Up
4. Results
5. Conclusion and Future Work

The German Auction in 2015

The German Auction in 2015

Environment of the German Auction

- Auction format: SMRA *(Simultaneous Multi-Round Auction)*
- Duration: 4 weeks
- Revenue: EUR 5.081bn
- Frequency bands: 700 MHz (LTE),
  900 MHz (LTE/GSM, ***cap at 3 blocks***)
  1800 MHz (LTE/GSM)
  1500 MHz
- Participants: TEF, DT, VOD

Comparison of the Auction Formats

Auction Formats

SMRA

(Simultaneous Multi-Round Auction)

- Extension of English Auction with **multiple items**
- **Single item** bids
- Round based fashion with ascending prices and **increments**
- Highest bid provisionally wins item
- Set of **actitivity rules** (e.g. eligibility points)
- Bidding until no new bids submitted

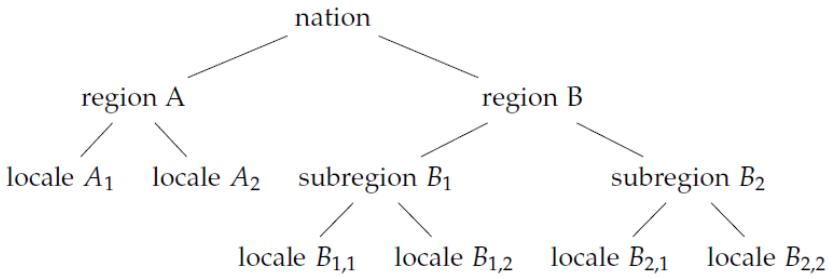
- often resolves in efficient allocations [2]
- Well established & simple format

- Strategical challenges in environments with complementarities

HPB

(Hierarchical Package Bidding)

- **Package bidding** allowed
- Items in tree like **hierarchy** [3]
- Efficient computation of allocation & prices Excess prices for packages handed down to item level *"lump-sum taxes"* [4]



Example of a HPB hierarchy

Simulation Set-Up

Simulation Set-Up

The Bidders‘ Valuation

- A **baseline model** was chosen: TEF’s mean bids for 1800 MHz (= baseline)
- Scaling of bidder‘s valuation with **spectrum relation** $\delta_{spec-rel}$ and **bidder strength** s_{MNO}

$\delta_{spectrum-relation}$	
$\delta_{1800-700}$	3
$\delta_{1800-900}$	2
$\delta_{1800-1800}$	1

s_{MNO}	
s_{TEF}	1
s_{DT}	1,25
s_{VOD}	1,15

$$V_{MNO}^{700} = V_{TEF}^{1800} * \delta_{1800-700} * s_{MNO}$$
$$V_{MNO}^{900} = V_{TEF}^{1800} * \delta_{1800-900} * s_{MNO}$$
$$V_{MNO}^{1800} = V_{TEF}^{1800} * \delta_{1800-1800} * s_{MNO}$$

- **Complementarities** modeled as multiples of item valuation in resp. band

$$V_{MNO}^{900_3} = V_{MNO}^{900} * \beta_{900_3}$$
$$V_{MNO}^{1800_4} = V_{MNO}^{1800} * \beta_{1800_4}$$

Simulation Set-Up

The Value Model

$$
\begin{aligned}
v : (q_{700}, q_{900}, q_{1800}) &\longrightarrow && \mathbb{R} \\
v_{MNO}(q_{700}, q_{900}, q_{1800}) &= && v_{700}(q_{700}) + v_{900}(q_{900}) + v_{1800}(q_{1800}) \\
v_{700}(q_{700}) &= && V_{MNO}^{700} * q_{700} \\
v_{900}(q_{900}) &= && V_{MNO}^{900} * q_{900} + \mathbb{1}_{\{q_{900} \geq 3\}} V_{MNO}^{900_3} \\
v_{1800}(q_{1800}) &= && V_{MNO}^{1800} * q_{1800} + \mathbb{1}_{\{q_{1800} \geq 4\}} V_{MNO}^{1800_4}
\end{aligned}
$$

Bonuses based on [1]:

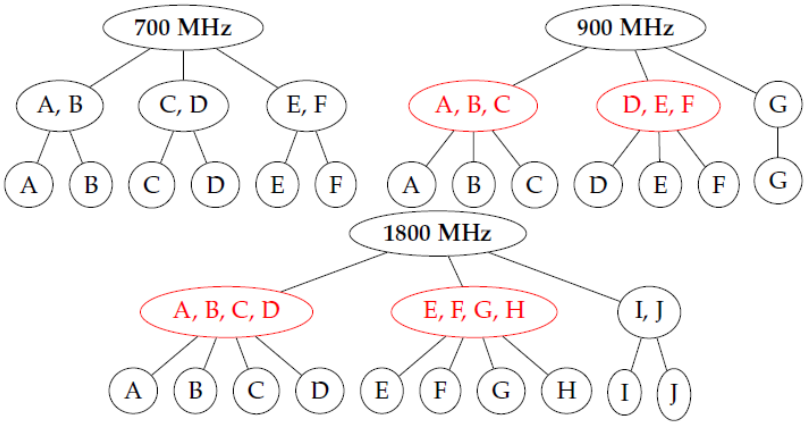
- 900 MHz: large incremental value for three blocks (2 LTE + 1 GSM or 3 GSM)
- 1800 MHz: blocks of 4 or 6 blocks (LTE), *but only 4 item bundle modeled*

Simulation Set-Up

The HPB Hierarchies

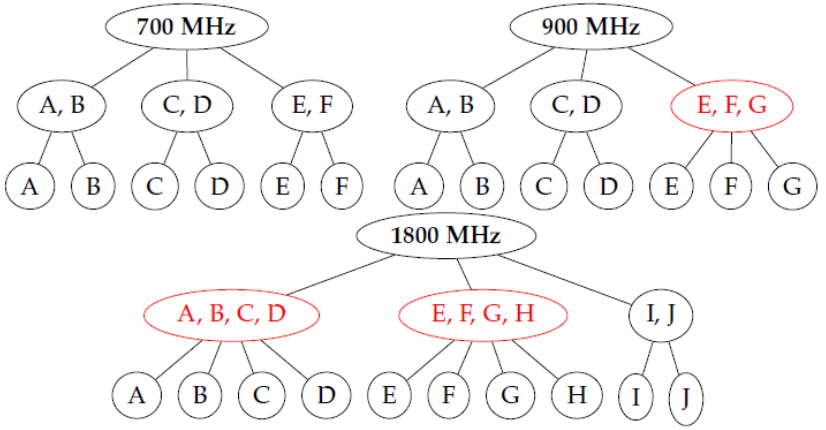
- two different hierarchies with **varying competition levels**
- explore effect of hierarchy on auction performance

$H_{competition}$



*red packages induce bonus

$H_{\text{vm-predict}}$



*red packages induce bonus

Simulation Set-Up

The Selector Model (MILP, *extension of an Additive Payoff Selector*)

$$\text{maximize} \quad \sum_{i \in Items} ass_i * V_i + b_{900} * bonusV_{900} + b_{1800} * bonusV_{900}$$
$$+ \varepsilon * \left[\sum_{p \in Hierarchy_{900bonus}} m_p + \sum_{p \in Hierarchy_{1800bonus}} m_p \right]$$

$$\text{subject to} \quad \sum_{i \in Items_{900}} ass_i \geq 3 * b_{900} \qquad (Bonus\ in\ 900\ MHz)$$

$$\sum_{i \in Items_{1800}} ass_i \geq 4 * b_{1800} \qquad (Bonus\ in\ 1800\ MHz)$$

$$\sum_{i \in Items_{900}} ass_i \leq 3 \qquad (Caps\ in\ 900\ MHz)$$

$$\sum_{i \in p} ass_i \geq |p| * m_p \quad \forall p \in Hierarchy_{900bonus} \cup Hierarchy_{1800bonus}$$

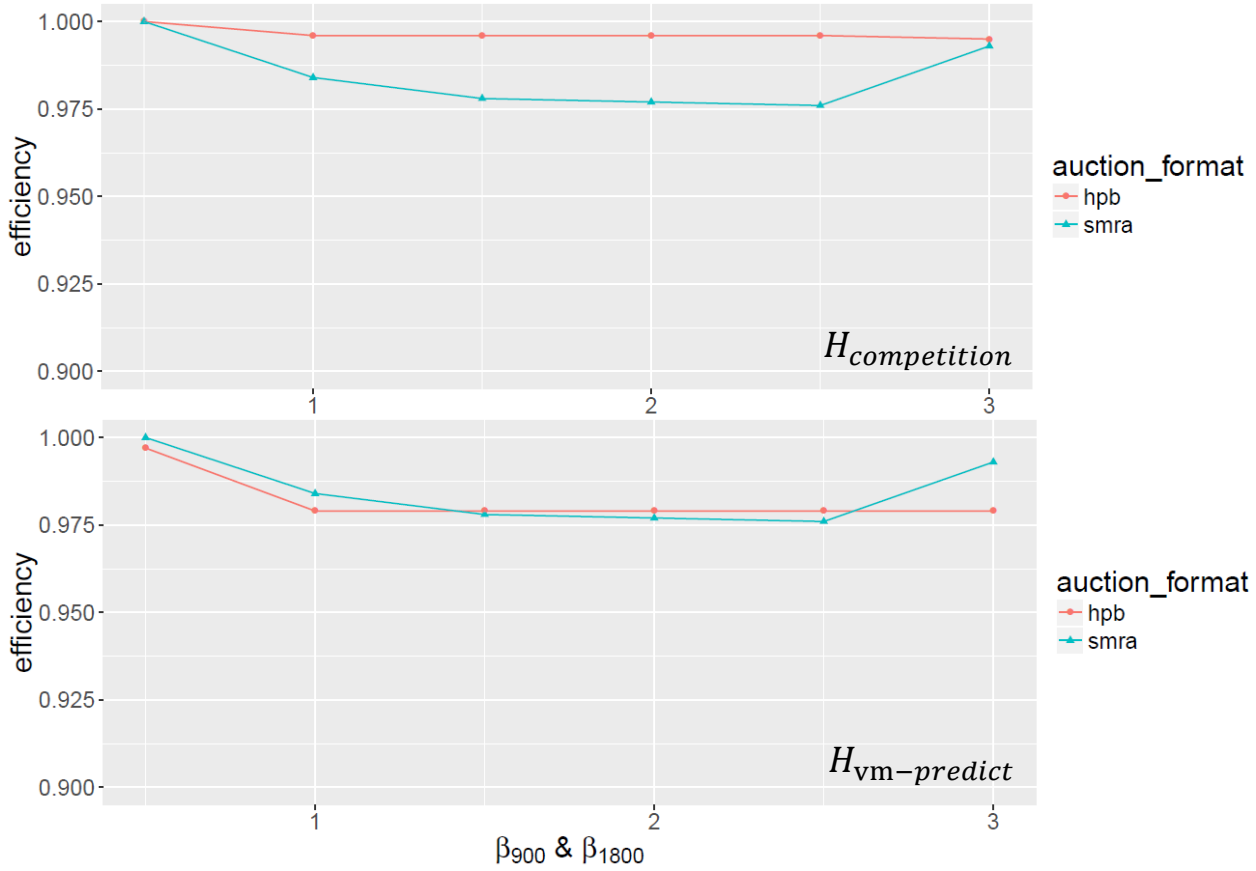
$$(Preemptive\ bundle\ selection)$$

$$\text{where} \quad V_i, bonusV_{900}, bonusV_{1800} \in \mathbb{N}, \quad \forall i \in Items$$
$$ass_i, b_{900}, b_{1800} \in \{0,1\}$$
$$m_p \in \{0,1\}, \quad \forall p \in Hierarchy$$

Results

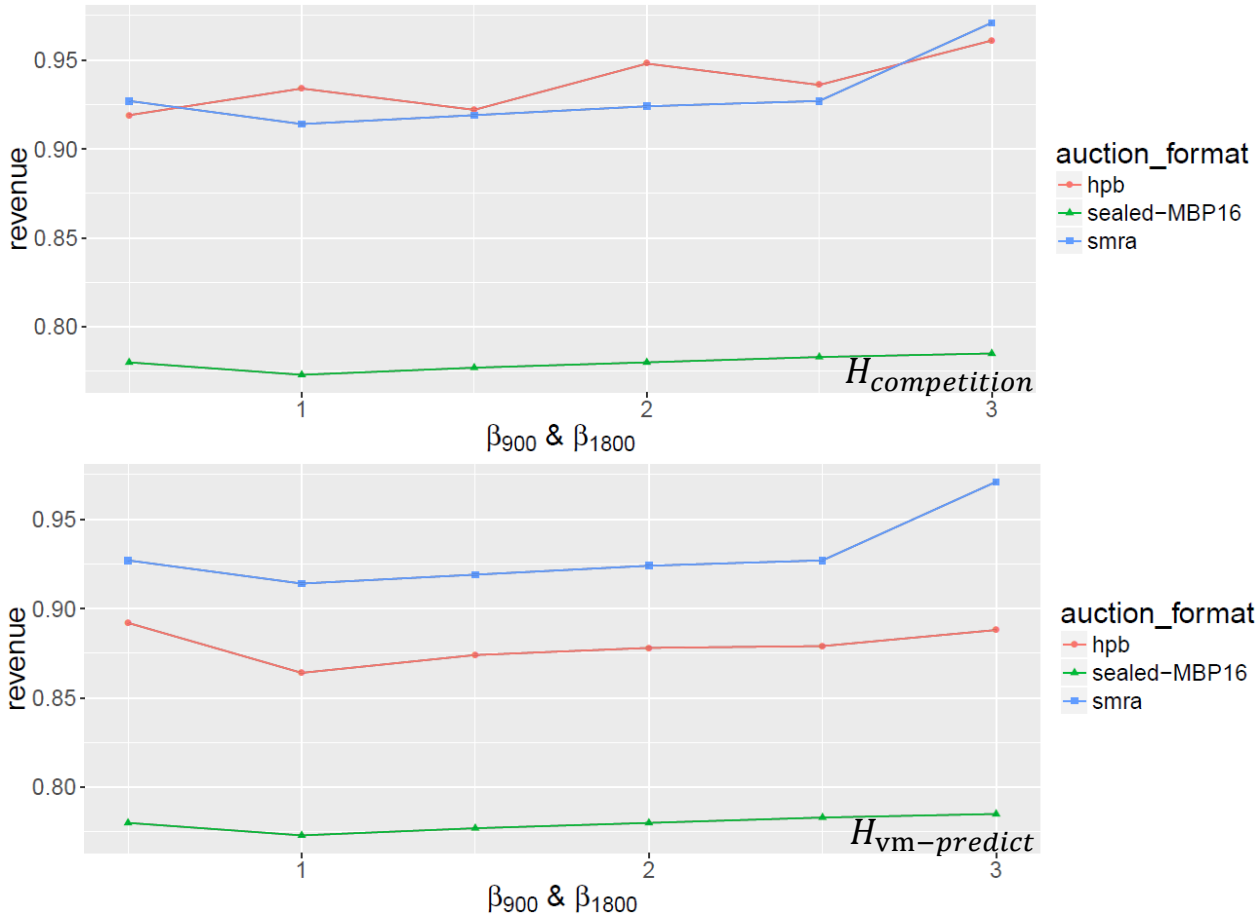
Results

Efficiency – impact of the bonus valuation β and the hierarchies



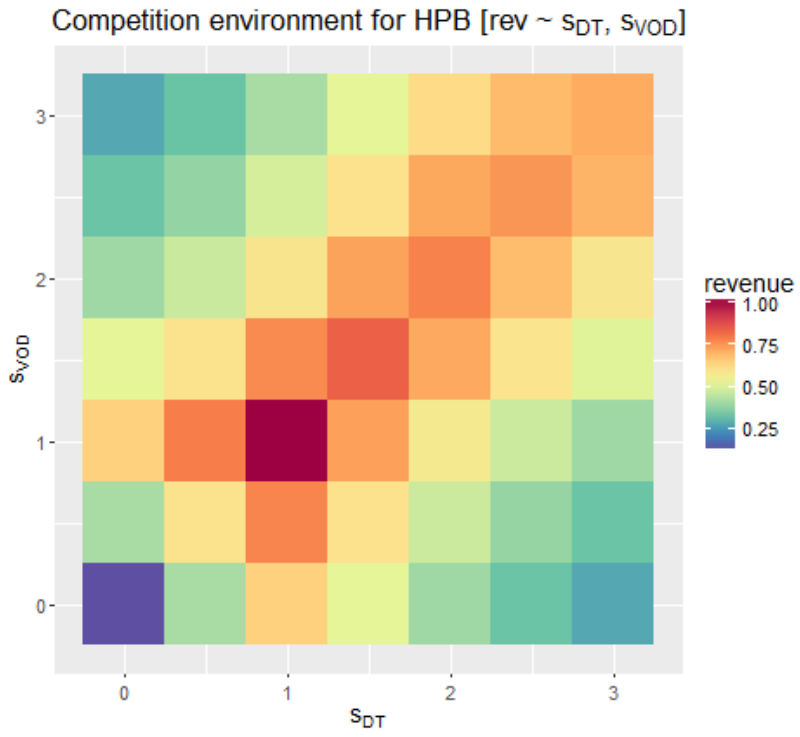
Results

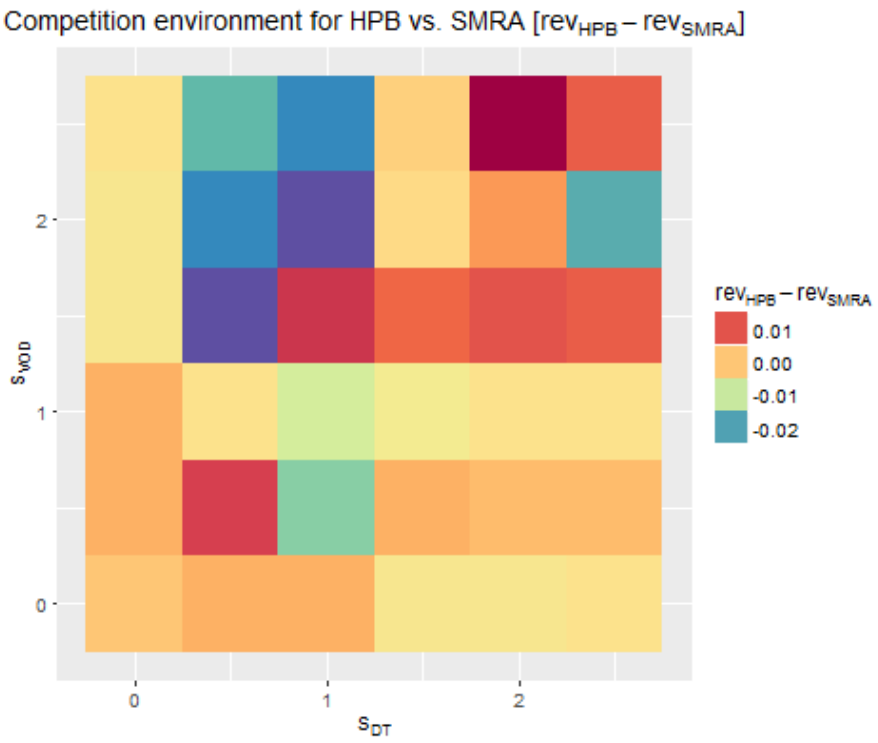
Revenue – impact of the bonus valuation β and the hierarchies



Results

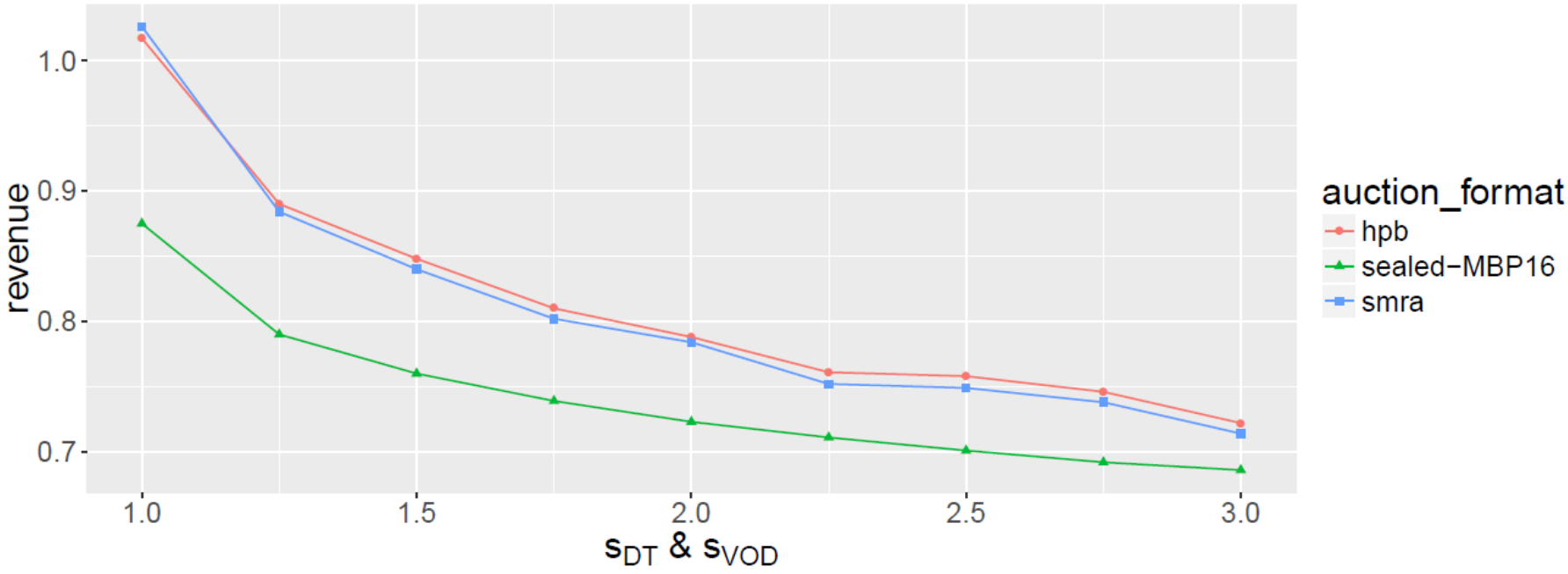
Revenue – impact of the competition environment ($H_{competition}$)





Results

Revenue – impact of the competition environment ($H_{competition}$)



Summary of the Results

	Hierarchy	Impact of β	Impact of s
Efficiency	$H_{competition}$	$HPB \succ SMRA$	$HPB \equiv SMRA$ when $s \geq 1.5$
	$H_{vm-predict}$	$HPB \approx SMRA$	$HPB \prec SMRA$, $when\ s > 1$
Revenue	$H_{competition}$	$HPB \succ SMRA$	$HPB \succ SMRA$ $rapidly\ decreasing$
	$H_{vm-predict}$	$HPB \prec SMRA$	$HPB \prec SMRA$

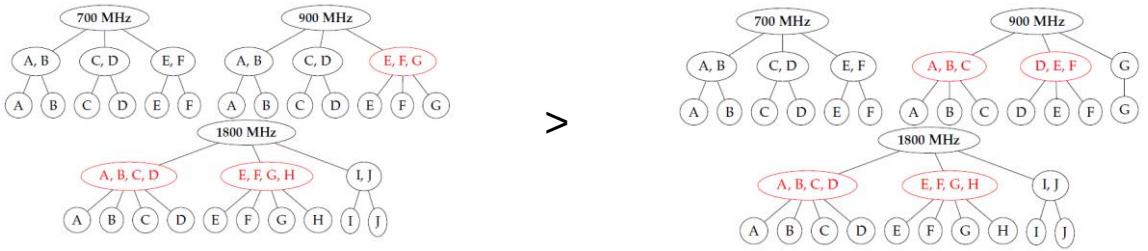
Conclusion and Future Work

- HPB might help to **improve bidder communication**
  - more **efficient allocations** ▲
  - **less revenue** ▼

- HPB performance was **more stable** in relation to different valuations of complementarities

- **Hierarchy** greatly **influences** auction **outcome**
  - SMRA performed better in less competitive hierarchy

  → Hierarchy is key for well perfoming HPB auctions



Thank you for your attention!

[5]

References

[1] M. Bichler, V. Gretschko, and M. Janssen. “Bargaining in Spectrum Auctions: A Review of the German Auction in 2015.” 2016.

[2] M. Bichler. The Simultaneous Multi-Round Auction Format. Munich: Technical University Munich, 2016, pp. 99–110.

[3] M. H. Rothkopf, A. Pekeˇc, and R. M. Harstad. “Computitional Manageable Combinatitional Auction.” In: Management science 44 (1998), pp. 1131–1147.

[4] J. K. Goeree and C. A. Holt. “Hierarchical package bidding: A paper & pencil combinatorial auction.” In: Games and Economic Behavior 70.1 (2010), pp. 146–169.

[5] https://xkcd.com/576/

Backup

The German Auction in 2015

Environment of the German Auction

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