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Econ@Tel. A Telecommunications Economic COST Network  
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# DIGITAL DIVIDEND IN EUROPE SIMULATING AUCTIONS

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## Introduction

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Wireless/mobile technologies are absolutely necessary for any agent who want to participate in the new ICTs markets playfield

- ★ Thus, a rational assignment and an efficient use of radio spectrum become *sine qua non* condition for the ICT sector development
- ▶ The economic efficiency would be maximum when, from the combination of possible uses of the resource (the spectrum), the one valid for “producing” the services optimising the usefulness of the agents present in the market was chosen

## Reforms in spectrum management policy

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- New technological and market circumstances make appear the traditional model as excessively complex and lacking of flexibility
- There are three possible paths leading to change
  - ▶ Modifications in the conditions of the allocated license
    - Relaxation of some clauses but, especially, authorisation of the transmission of rights (secondary spectrum trade)
  - ▶ Modifications in the definition of the licenses
    - Avoiding to bind the license to specific technologies (technological neutrality) or even to specific services (service neutrality)
  - ▶ Modifications in the license-allocation mechanisms
    - ➡ *Usage of auctions*

## Spectrum auctions

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- The first country in using spectrum auctions was New Zealand in 1989
- United States, Canada or Australia also used auctions during the nineties
- The turning point for auctions happened in 2000-2001 with European 3G (UMTS) licences auctions
- The “digital dividend” resulting from the television analogue switch off represents a great opportunity for introducing some criteria attempting to increase the efficiency in the usage of the spectrum
- The United States 700 MHz FCC wireless spectrum auction has put the focus on auctions

# Structure

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- Model assumptions
  - ▶ Spectrum to be auctioned
  - ▶ Auction design
  - ▶ Participants in the auction
  - ▶ Willingness to pay for spectrum
  - ▶ Modelled scenarios
- Experiments methodology
- First results
- Further stages

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## Spectrum to be auctioned

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- Digital dividend of 120 MHz
- 15 lots of 8 MHz each
- No consideration of interleaved spectrum
- National licences
- No significant differences between blocks

# Auction design

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- Open auction (bidders can see each others bids)  
Sealed bid auction (each bid is secret)
- Sequential auction (bidders bid for one lot after another)  
Simultaneous auction (bids for all lots at the same time)
  - SMR, Simultaneous Multiple-Round Auction
  - One single round
- Individual bidding (bids for individual items)  
Combinatorial or package bidding (bids for combinations of items)
- Generic lots (“substitute goods”)
- First-price auction (PWYB, pay what you bid)



## Participants in the auction

	Bidder	Market target	Expectations / Interest	Number of lots
1	TV BROADCASTER	DTT - SD	Medium	3-12
2		DTT - HD	Medium	3-15
3		DTT - SD / DTT - HD	Limited / Limited	3-15
4		DTT - SD / MobTV	Limited / Medium	1-15
5	MOBILE OPERATOR	Voice+Data (900)	Limited	1-8
6		Voice+Data (900) / MobTV	Limited / Medium	1-14
7		Voice+Data (no 900) / MobTV	High / Limited	1-14
8		Voice+Data (no 900) / Data	High / Limited	1-15
9	NEW ENTRANT	DTT - SD	High	3-12
10		DTT - HD	High	3-15
11		Voice+Data (no 900)	High	1-8
12		Data	Medium	1-8
13		Data	High	1-8
14		MobTV	Limited	1-6
15		MobTV	High	1-6

DTT - SD	Digital terrestrial television (standard definition)
DTT - HD	Digital terrestrial television (high definition)
MobTV	Mobile television
Voice+Data (900)	Mobile communications (having already spectrum in the 900 MHz band)
Voice+Data (no 900)	Mobile communications (not having spectrum in the 900 MHz band)
Data	Mobile broadband (specialist "data only" product)

## Willingness to pay for spectrum

- Maximum and minimum values adapted from range of *producer plus consumer value* estimated by Ofcom
- Three ranges of “interest values”
- Synergies between lots (example “24 MHz objective”)

Number of lots	Synergy value	Coefficient
1	0,5	0,167
2	0,75	0,500
3	1	1,000
4	0,9	1,300
5	0,8	1,567
6	0,7	1,800
7	0,5	1,967
8	0,25	2,050
9	0	0

## Willingness to pay for spectrum: an example

MOBILE (DATA CENTRIC)			
	Low value scenario		High value scenario
Ofcom data	1		2,5
€/pound change	0,7413		0,7413
Producer/consumer sharing	0,5		0,5
Number of agents	2		2
Spectrum acquired	24 MHz		24 MHz
Other variables in the model	Dominants		Entrants
	Moderated demand		High demand
	<b>Minimum</b>		<b>Maximum</b>
<b>Adapted value(M€)</b>	<b>185</b>		<b>463</b>
Limited interest	185	255	324
Medium interest	255	324	394
High interest	324	394	463

## Modelled scenarios

A. Service neutrality

B. Pre-assigned blocks

	B1		B2		B3		B4	
	Lots	MHz	Lots	MHz	Lots	MHz	Lots	MHz
DTT	12	96	8	64	4	32	0	0
Mobile TV	0	0	2	16	7	56	5	40
Mobile communications	3	24	5	40	4	32	10	80
		120		120		120		120

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# Methodology

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- An efficient simulator for combinatorial first-price sealed bid auctions has been developed
- The auctioneer determines the combination of feasible bids that maximizes revenues, i.e., solves the Winner Determination Problem (WDP)
  - ▶ To work out the WDP a heuristic search algorithm has been implemented. The selected algorithm is an A\* based on a branch on bids (BOB) with an efficient heuristic formulation based on price
- All the scenarios will be run 100 times in a dual Intel QuadCore® processor machine with 8Gb of RAM memory
  - ▶ All the bidders' valuations change in each execution following a Gaussian distribution between spectrum valuation limits

# Structure

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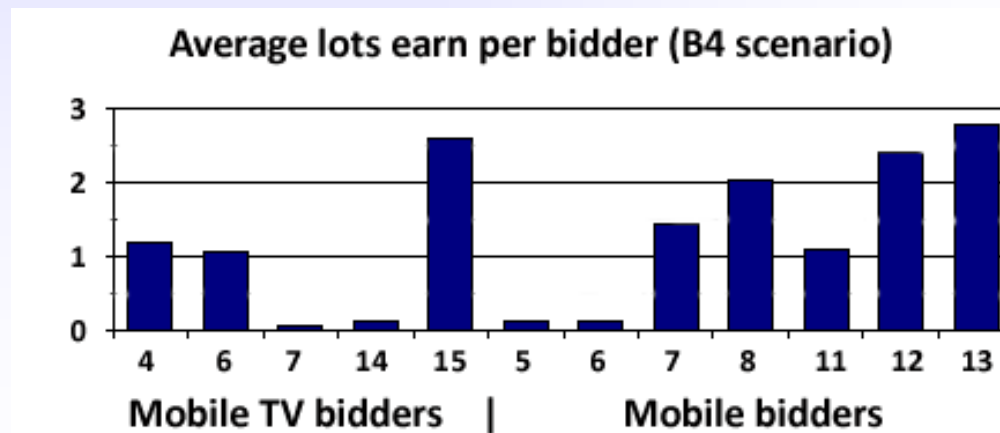
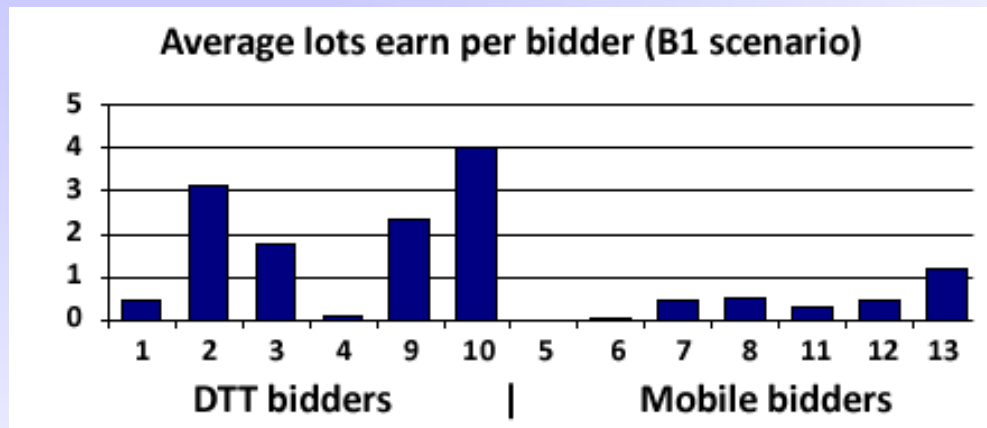
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# First results (I)

B1 SCENARIO				B4 SCENARIO			
SELLER'S INCOME (MILLIONS OF EURO)				SELLER'S INCOME (MILLIONS OF EURO)			
	DTT	Mobile	Total		Mob.TV	Mobile	Total
Mean	831.96	288.91	1120.87	Mean	776.31	914.03	1690.35
Median	835.15	288.36	1111.24	Median	768.90	930.46	1690.36
Stand. Deviation	122.02	50.90	134.06	Stand. Deviation	125.04	131.55	173.78
Max.	1072.30	415.51	1378.03	Max.	1008.47	1161.35	2083.43
Min.	408.92	169.95	639.77	Min.	464.01	550.35	1280.17
Average price per lot	69.33	96.30	74.72	Average price per lot	155.26	91.40	112.69



## First results (II)



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## Further stages

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- Different size of digital dividend?
- Different scenarios?
- Other bidders?
- Other potential synergies (neighbour countries)?
- Whole-Europe auctions?
- Other type of auctions?

SMR, Simultaneous Multiple-Round Auction?

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