Market Design inspired by Robert Wilson

Peter Cramton

Professor of Economics

University of Cologne

www.cramton.umd.edu

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Market design

- Establishes rules of market interaction
- Economic engineering
  - Economics
  - Computer science
  - Operations research
  - Psychology
  - Engineering

Market design accomplishments

- Improve allocations
- Improve price information
- Reduce risk
- Enhance competition
- Mitigate market failures

Applications

Matching

- Marriage
- Jobs
- Schools
- Kidneys
- Homes

Auctions

- *Electricity markets*
  - *Climate policy*
- *Communication markets*
- *Transportation markets*
- *Financial securities*
- Natural resource auctions (timber, oil, diamonds, pollution emissions)
- Procurement

Innovation in a few words

- Electricity
  - Open access
  - Pay for performance
- Communications
  - Auction spectrum
  - Open access
- Transportation
  - Price congestion
- Climate policy
  - Price carbon
- Financial securities
  - Make time discrete
  - Improve preference expression

Resistance to market reforms is the norm:
Peter to regulator, "I can save you $10 billion."
Wall Street to regulator, "Hey, that's my $10 billion."
Distribution trumps efficiency

Milton Friedman

There is enormous inertia—a tyranny of the status quo—in private and especially governmental arrangements. Only a crisis—actual or perceived—produces real change. When that crisis occurs, the actions that are taken depend on the ideas that are lying around. That, I believe, is our basic function [as market designers]: to develop alterna-tives to existing policies, to keep them alive and available until the politically impossible becomes politically inevitable.

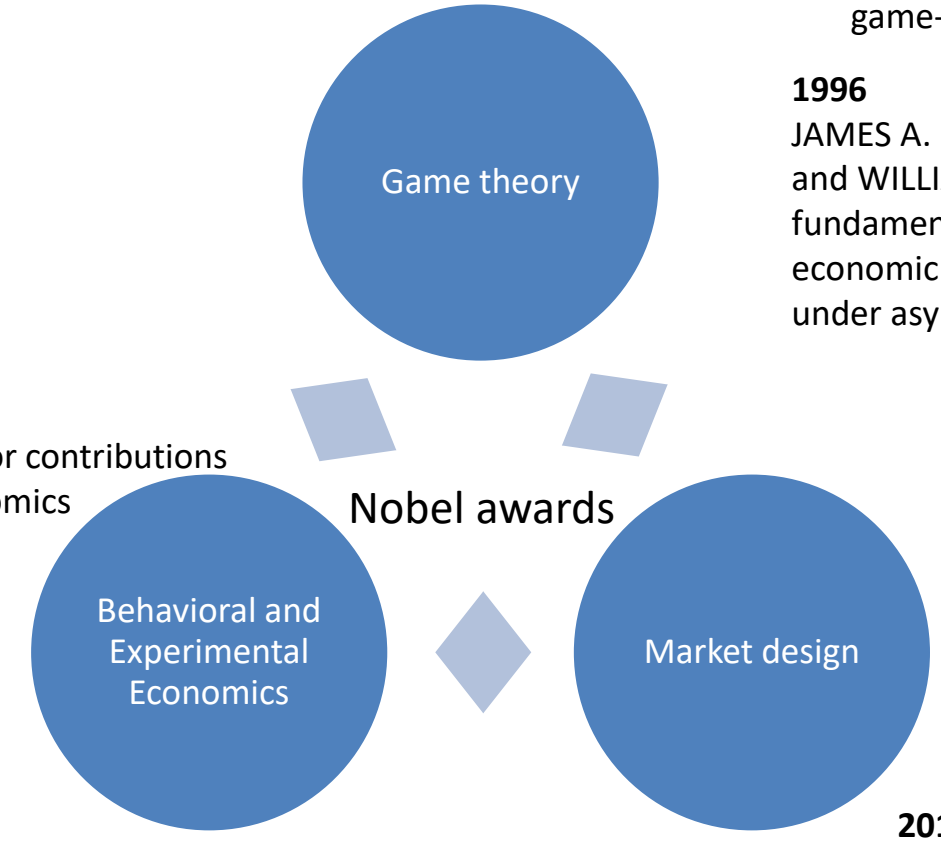
1994
JOHN C. HARSANYI ,
JOHN F. NASH and
REINHARD SELTEN for their pioneering analysis of equilibria in the theory of non-cooperative games

2001
GEORGE A. AKERLOF, A. MICHAEL SPENCE, and JOSEPH E. STIGLITZ, for their analyses of markets with asymmetric information

2005
ROBERT J.AUMANN and
THOMAS C. SCHELLING for having enhanced our understanding of conflict and cooperation through game-theory analysis

2002
VERNON L. SMITH for having established laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms, and

DANIEL KAHNEMAN for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty



1996
JAMES A. MIRRLEES
and WILLIAM VICKREY for their fundamental contributions to the economic theory of incentives under asymmetric information

2017
RICHARD THALER for contributions to behavioral economics

2007
LEONID HURWICZ, ERIC S. MASKIN, and ROGER B. MYERSON for having laid the foundations of mechanism design theory

2016
BENGT HOLMSTRÖM and
OLIVER HART for contributions to contract theory

2014
JEAN TIROLE for his analysis of market power and regulation

1978
HERBERT A. SIMON for his pioneering research into the decision-making process within economic organizations

2009
ELINOR OSTROM for her analysis of economic governance, especially the commons

2012
ALVIN E. ROTH and LLOYD SHAPLEY for the theory of stable allocations and the practice of market design

Objectives

- Efficiency
- Simplicity
- Transparency
- Fairness

It is good to keep these goals in mind whenever designing a market

Applications

Electricity market design

Spectrum auction design

Future of mobile communications

Future of transportation

Future of financial markets

Electricity

Goal of electricity markets:
Reliable electricity at least cost

Short-run efficiency

Least-cost operation of existing resources

Long-run efficiency

Right quantity and mix of resources

Open access!

Challenges of electricity markets

- Must balance supply and demand *at every instant*
- Physical constraints of network and resources
- Shocks in supply
  - Transmission line or generator outage
  - Intermittent resources: wind and solar
- Absence of demand response
- Climate policy

A successful market design

- Get the spot market right
  - Day ahead
    - Scheduling and unit commitment
  - Real time
    - Bid-based security constrained economic dispatch
- Forward trade to manage risk and support long-run investment

ERCOT Load with Real Time and Day Ahead Prices
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
5/1/2017
5/8/2017
5/15/2017
5/22/2017
5/29/2017
6/5/2017
6/12/2017
6/19/2017
6/26/2017
7/3/2017
7/10/2017
7/17/2017
7/24/2017
7/31/2017
8/7/2017
8/14/2017
8/21/2017
8/28/2017
Real Time Price Average
Day Ahead Price Average
ERCOT Load ('0000 MWh)

STP-to-Whitepoint 345-kV transmission structures

Tatton Substation

Transmission Damage

- **52 inches** of rainfall in southeast Texas
- Harvey made landfall **multiple times**
  - **Category 4** near Port Aransas, Texas
  - **Tropical storm** in Cameron, Louisiana
- More than **42,000** lightning strikes
- Record number of tornado warnings in southeast Texas

Peter Cramton @pcramton · 39s

The concept of Donald J. Trump was created by and for the Russians in order to destabilize the West.

Global Carbon Pricing

The Path to Climate Cooperation

edited by Peter Cramton, David JC MacKay,
Axel Ockenfels, and Steven Stoft

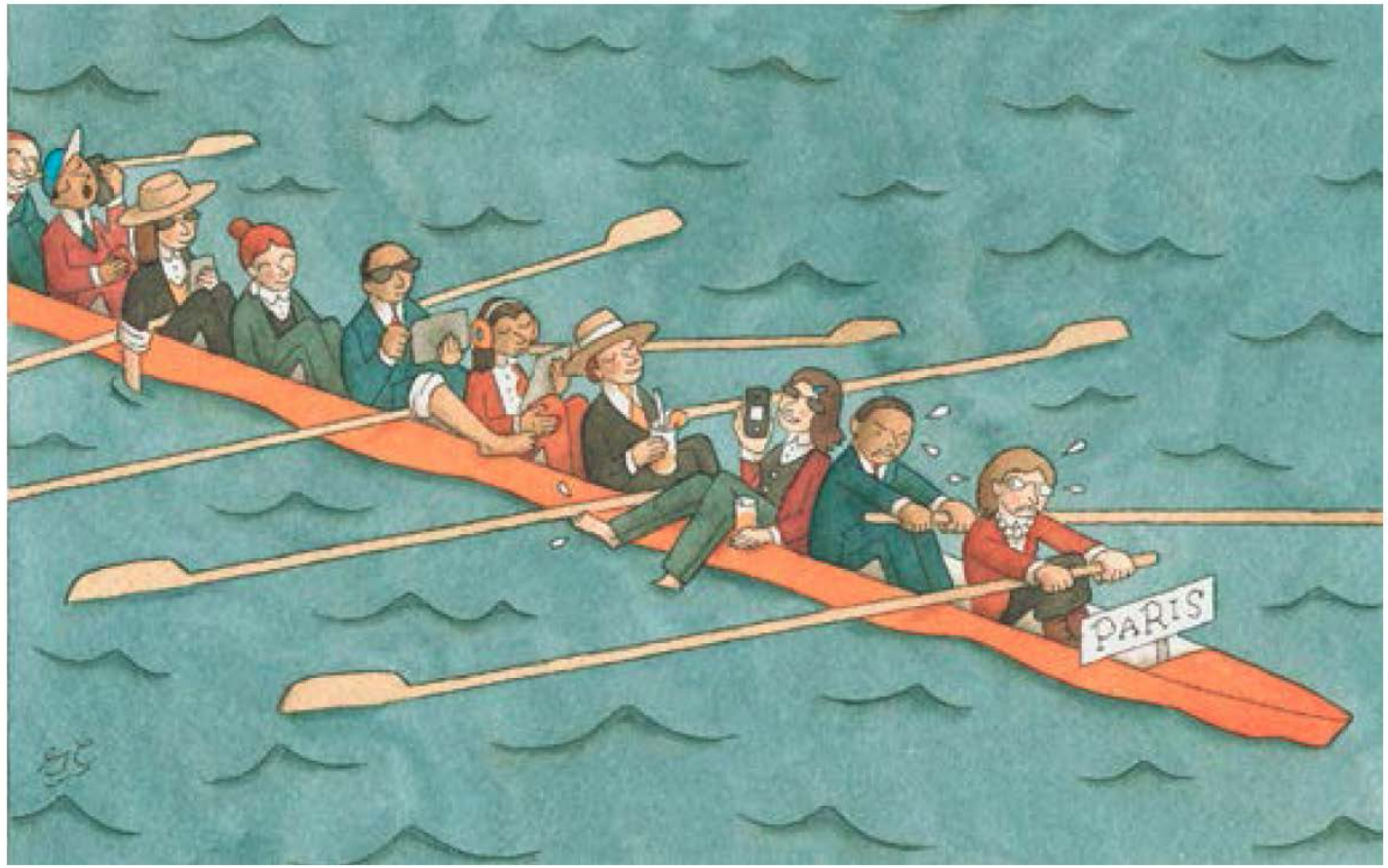
Contributors

Richard N. Cooper
Peter Cramton
Ottmar Edenhofer
Christian Gollier
Éloi Laurent
David JC MacKay
William Nordhaus
Axel Ockenfels
Ian Parry
Joseph E. Stiglitz
Steven Stoft
Jean Tirole
Martin L. Weitzman

Why price carbon?

- Direct
- Efficient
- Transparent
- *Promotes international cooperation*

ILLUSTRATION BY GREG CLARKE



Price carbon — I will if you will

David MacKay, Peter Cramton, Axel Ockenfels and Steven Stoft), *Nature*, 526, 315-316, 15 October 2015.

National solution: carbon dividends

THE CONSENSUS CLIMATE SOLUTION

The Founding Members of the Climate Leadership Council believe that America needs a consensus climate solution that bridges partisan divides, strengthens our economy and protects our shared environment.

The Council's carbon dividends solution embodies the conservative principles of free markets and limited government. It also offers an equitable, popular and politically-viable way forward, paving the way for a much-needed bipartisan climate breakthrough.

Our carbon dividends program is based on four interdependent pillars:

1. A gradually rising and revenue-neutral carbon tax;
2. Carbon dividend payments to all Americans, funded by 100% of the revenue;
3. The rollback of carbon regulations that are no longer necessary; and
4. Border carbon adjustments to level the playing field and promote American competitiveness.

This plan would achieve significantly greater emissions reductions than all current and prior climate regulations, while helping America's businesses and workers get ahead. In fact, the bottom 70% of Americans would be financially better off.

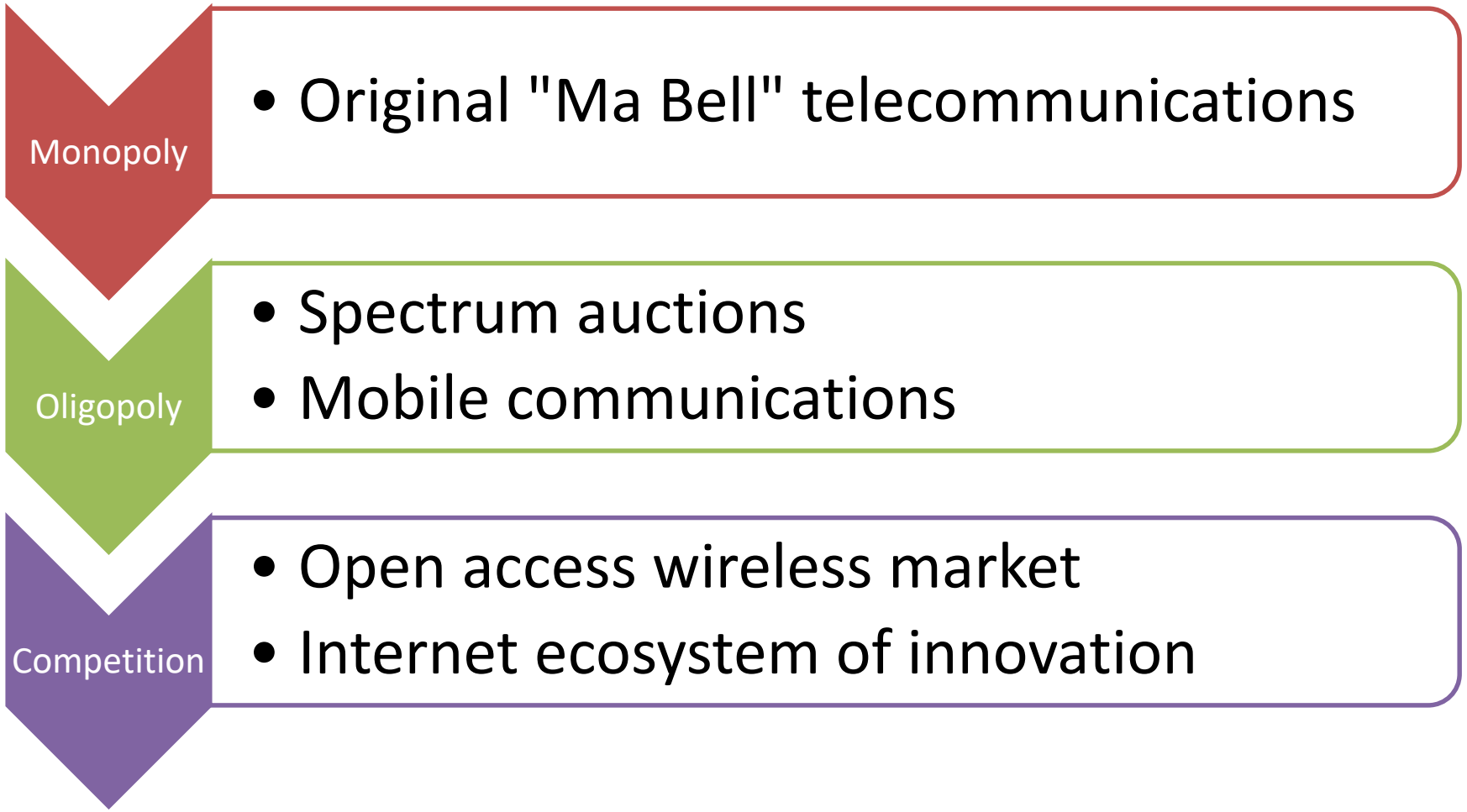
Our carbon dividends solution is: Pro-Environment, Pro-Growth, Pro-Jobs, Pro-Competitiveness, Pro-Business and Pro-National Security.

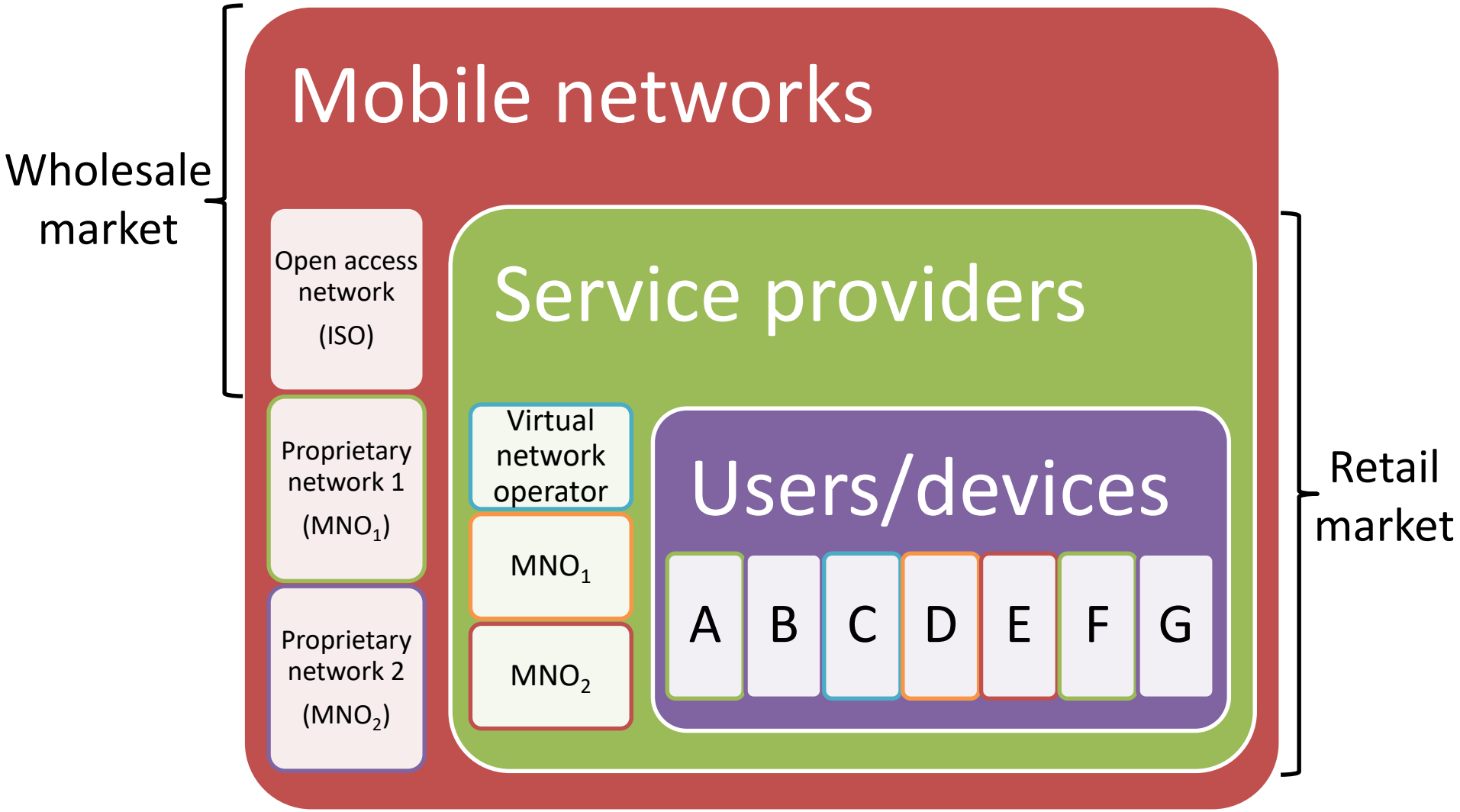
Working with a range of constituencies, the Climate Leadership Council will develop and promote a consensus climate solution based on these pillars.

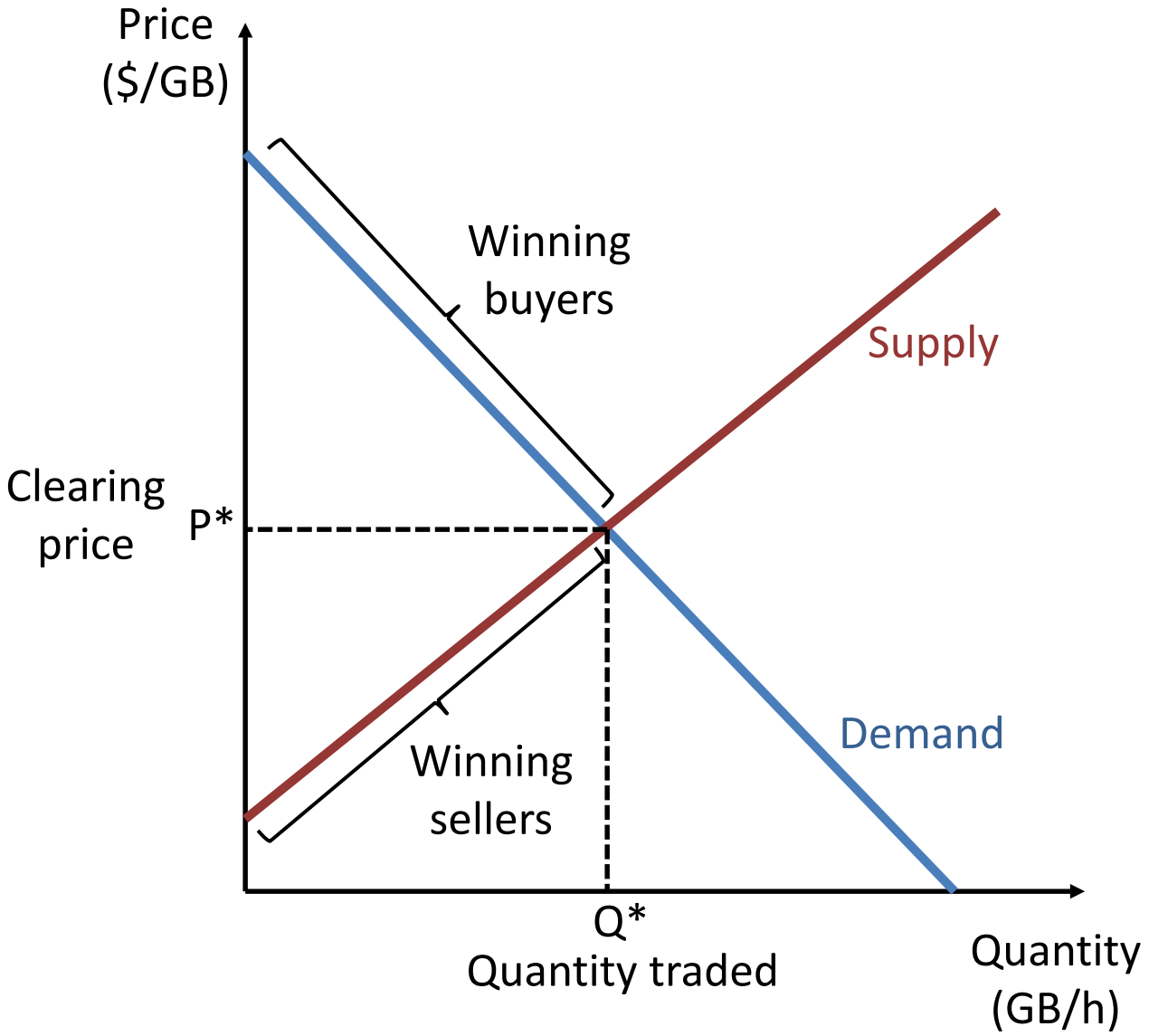
WSJ ad, 20 June 2017

The Future of Mobile Communications

From monopoly to vibrant competition




Wholesale market
Mobile networks
Open access network (ISO)
Proprietary network 1 (MNO_1)
Proprietary network 2 (MNO_2)
Service providers
Virtual network operator
MNO_1
MNO_2
Users/devices
A
B
C
D
E
F
G
Retail market


Price
($/GB)
Winning
buyers
Supply
Clearing
price
P*
Demand
Winning
sellers
Q*
Quantity traded
Quantity
(GB/h)

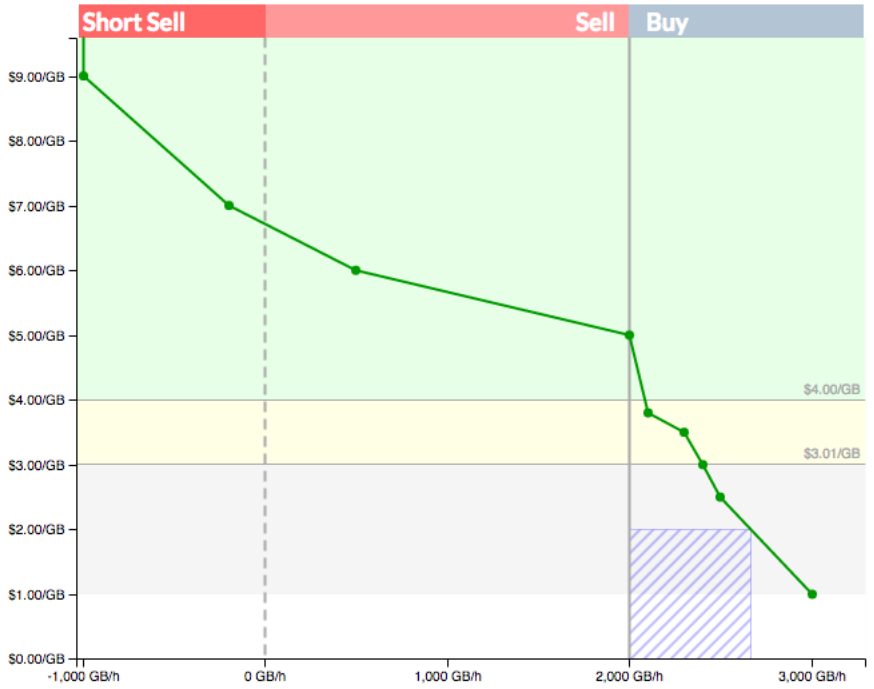
Sample demand for bidder

Manhattan (peak) monthly

Manhattan (Peak) At $ | /GB hold GB/h Add Cancel

	Price	Quantity	Change in Quantity	Commitment (180 hours)
Future Rounds				
	$9.00/GB	-1,000.000 GB/h	-3,000.000 GB/h	-$4,860,000
	$7.00/GB	-200.000 GB/h	-2,200.000 GB/h	-$2,772,000
	$6.00/GB	500.000 GB/h	-1,500.000 GB/h	-$1,620,000
	$5.00/GB	2,000.000 GB/h	0.000 GB/h	$0
Current Round				
	$4.00/GB	***2,083.333 GB/h***	***83.333 GB/h***	***$60,000***
	$3.80/GB	2,100.000 GB/h	100.000 GB/h	$68,400
	$3.50/GB	2,300.000 GB/h	300.000 GB/h	$189,000
Past Rounds				
	$3.00/GB	***2,400.000 GB/h***	***400.000 GB/h***	***$216,000***
	$2.50/GB	2,500.000 GB/h	500.000 GB/h	$225,000
	$2.00/GB	***2,666.667 GB/h***	***666.667 GB/h***	***$240,000***
Price Floor				
	$1.00/GB	3,000.000 GB/h	1,000.000 GB/h	$180,000

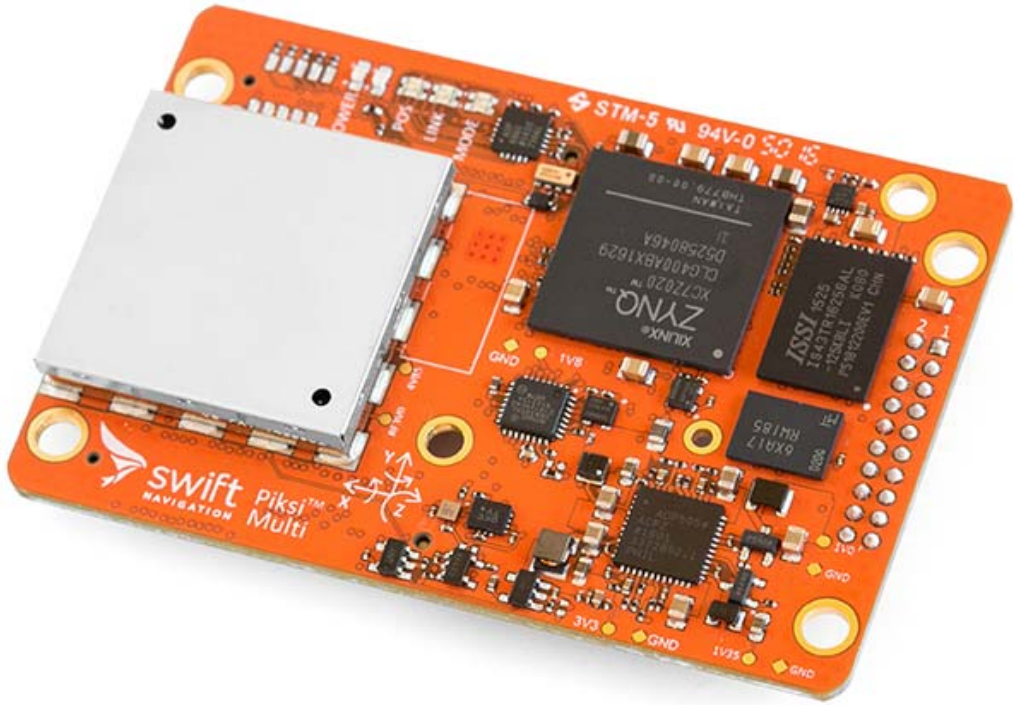
Your Forward Position: 2,000.000 GB/h **Published Maximum Supply:** 10,000.000 GB/h



The Future of Transportation

Step 1: Vehicle measurement of road use

- Real time kinematic
  - 2 cm accuracy
  - Retail cost $1000, but will drop dramatically to [$50 with scale]



Step 2: Congestion pricing

- addresses congestion externality (Vickrey 1963)
- addresses environmental externality
- encourages drivers to explore travel alternatives during peak times
- simplifies consumer decision-making
- improves safety
- allows joint optimization of all transport (roads and transit)
- provides essential information to direct scarce investment resources
- generates the funds that underlie that investment with non-distortionary taxes
- adopts basic fairness principles
- allows scarce road space to be allocated to those who value it most highly
- incentivizes technological innovations that reduce demand on scarce capacities

Incremental implementation

1. Identify issues with current system
2. Introduce measurement; simulate network
3. Introduce initial time-and-location prices (fixed!)
4. Re-estimate prices and introduce refined prices
5. Repeat until learn behavioral response
6. Introduce real-time pricing (e.g. adapts to shocks in supply)
7. Introduce forward purchase (establish sensible default plan)
8. Study long-term impact

The Future of Financial Markets

Budish, Cramton and Shim (2015)

- Speed race is built into current market design
- Speed race is costly
- Costs are borne by fundamental investors
- Frequent batch auctions eliminate speed race
  - Transforms competition on speed to competition on price
  - Computational benefits for traders, exchanges, and regulators

Smart Markets for Financial Securities: From Block to Flow Trading

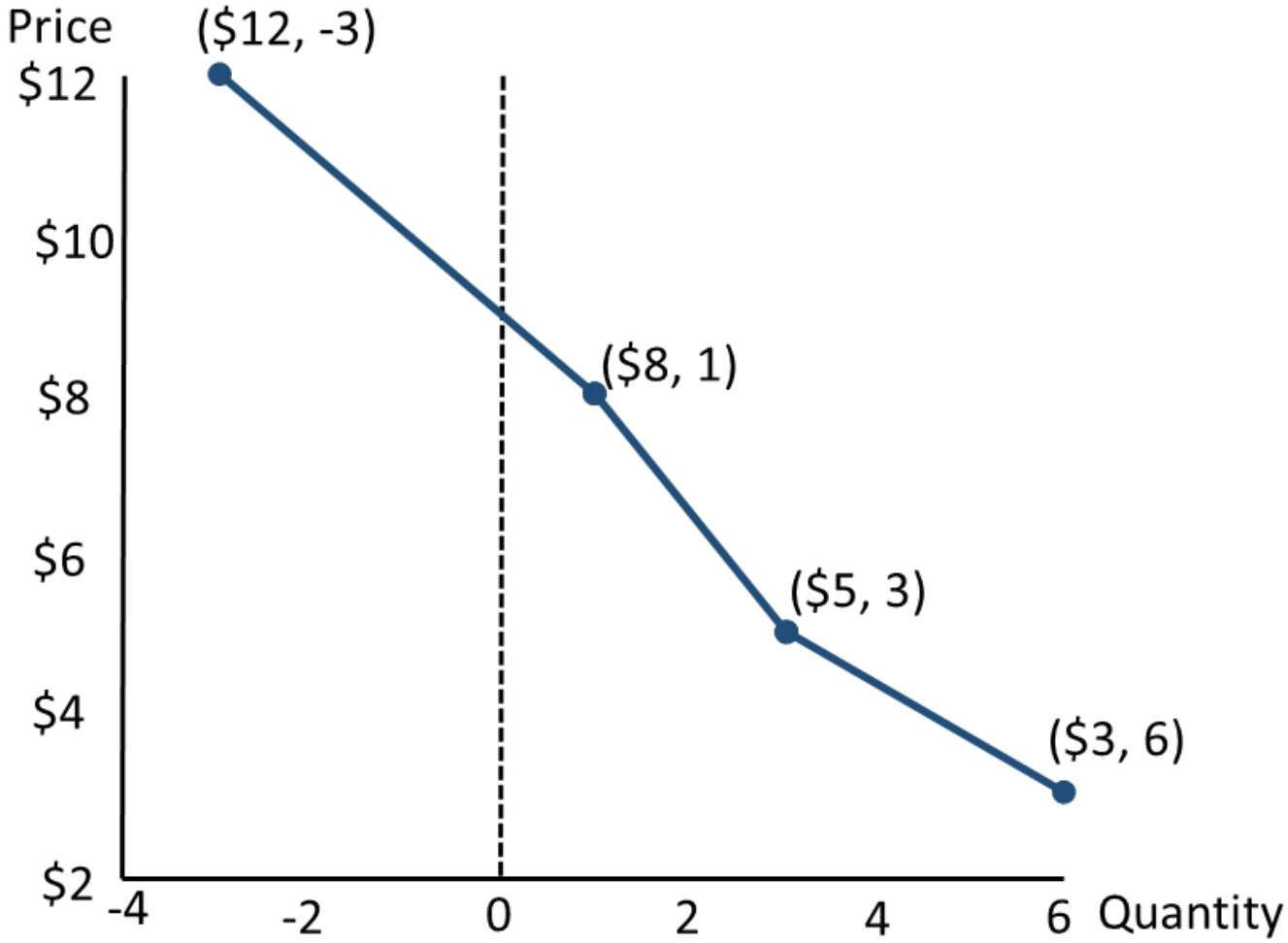
Eric Budish, Peter Cramton, Pete Kyle,
Mina Lee, David Malec, and David Parkes

Key elements

- Periodic clearing
- Sophisticated expression of preferences
- Optimization of gains from trade
- Improved outcome discovery, transparency, trust, and privacy

"At $1,730.22 I want to buy 10.1234 shares of Amazon per minute."

Preference expression: Piecewise-linear demand in flows



Maximize gains from trade (social welfare) s.t. linear constraints

Smart market

$$\underset{x,y}{\text{maximize}} \sum_{P\in\mathcal{P}} V_P(y_P) \quad \text{subject to}$$

$$y_o = \sum_{o'\in M^+(o)} x_{o',o} - \sum_{o'\in M^+(o)} x_{o,o'} \qquad \forall o \in O^+ \qquad : \mu_o$$

$$y_S = \sum_{o\in O(S)} r_S(\varphi_o)\cdot y_o \qquad \forall S \in \mathcal{S} \qquad : \sigma_S$$

$$y_C = r_C(\varphi_o)\cdot y_o \qquad \forall C \in \mathcal{C}, \forall o \in O(C) \qquad : \gamma_{C,o}$$

$$y_P \in [\underline{q}_P, \overline{q}_P] \qquad \forall P \in \mathcal{P} \qquad : \delta_P$$

$$x \geq 0$$

$$\underset{x,y,z}{\text{maximize}} \sum_{P\in\mathcal{P}} \sum_{i\in[k_P]} \left(\frac{m_{P,i}}{2} z_{P,i}^2 + p_{P,i} z_{P,i} \right) \quad \text{subject to}$$

$$y_P = \sum_{i\in[k_P]} z_{P,i} + \underline{q}_P \qquad \forall P \in \mathcal{P} \qquad : \alpha_P$$

$$y_o = \sum_{o'\in M^+(o)} x_{o',o} - \sum_{o'\in M^+(o)} x_{o,o'} \qquad \forall o \in O^+ \qquad : \mu_o$$

$$y_S = \sum_{o\in O(S)} r_S(\varphi_o) \cdot y_o \qquad \forall S \in \mathcal{S} \qquad : \sigma_S$$

$$y_C = r_C(\varphi_o) \cdot y_o \qquad \forall C \in \mathcal{C}, \forall o \in O(C) \qquad : \gamma_{C,o}$$

$$z_{P,i} \le \Delta_{P,i} \qquad \forall P \in \mathcal{P}, \forall i \in [k_P] \qquad : \overline{\alpha}_{P,i}$$

$$z_{P,i} \ge 0 \qquad \forall P \in \mathcal{P}, \forall i \in [k_P] \qquad : \underline{\alpha}_{P,i}$$

$$x_{o,o'} \ge 0 \qquad \forall (o,o') \in M^+ \qquad : \underline{\mu}_{o,o'}$$

Features of market outcome

Competitive equilibrium quantities and prices exist and are unique when it matters (positive quantity traded and not perfect substitutes)

Outcome maximizes as-bid social welfare s.t. constraints

Incentives for truthful bidding are good (and excellent for most liquid products)

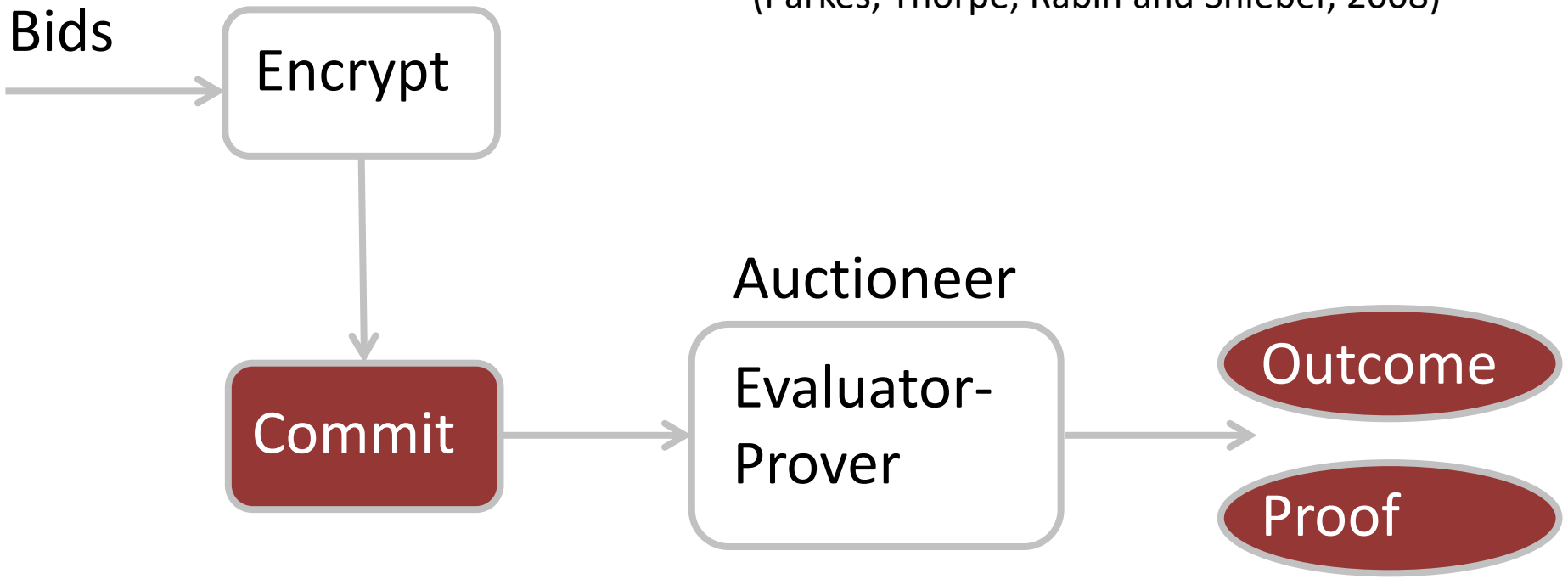
Outcome is as-bid envy free
(given prices, everyone gets their favorite bundle)

Scales to large number of products and participants

Compact expression of preference make this especially attractive for blockchain implementation

Trustworthy markets

(Parkes, Thorpe, Rabin and Shieber, 2008)



- *Random representation scheme* (Rabin et al.'07)
  - Provides proofs on demand; scalable.
- *Trust property*
  - If auctioneer deviates, auctioneer cannot prove correctness
  - No information about bids available to auctioneer before clearing

Market design innovation

- Electricity
  - ✓ Open access
  - ✓ Pay for performance
- Communications
  - ✓ Auction spectrum
  - – Open access
- Transportation
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- Climate policy
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  - – Improve preference expression

Plenty of work ahead!