Public Goods and Experimental Economics
—
Evidence on Coalition Formation

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Overview

- Some ideas on the role of experiments
- Individual public good provision
- Institution formation and cooperation among countries
- Experimental Evidence

The Role of Experiments

Talked about Behavioral Economics...

The Role of Experiments

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. . . where does Experimental Economics come in?

- Test theories and their predictions
- Observe unpredicted regularities
- Discriminate between alternative theories, test predictions
- Searching for facts where no theoretical predictions exist, often follow-up to previous experiments
- Whispering in the ears of princesses (policymakers), e.g. question of effects of certain new institutions, policy proposals

(Al Roth, Ch.1 in Kagel/Roth)

Some Notes on History

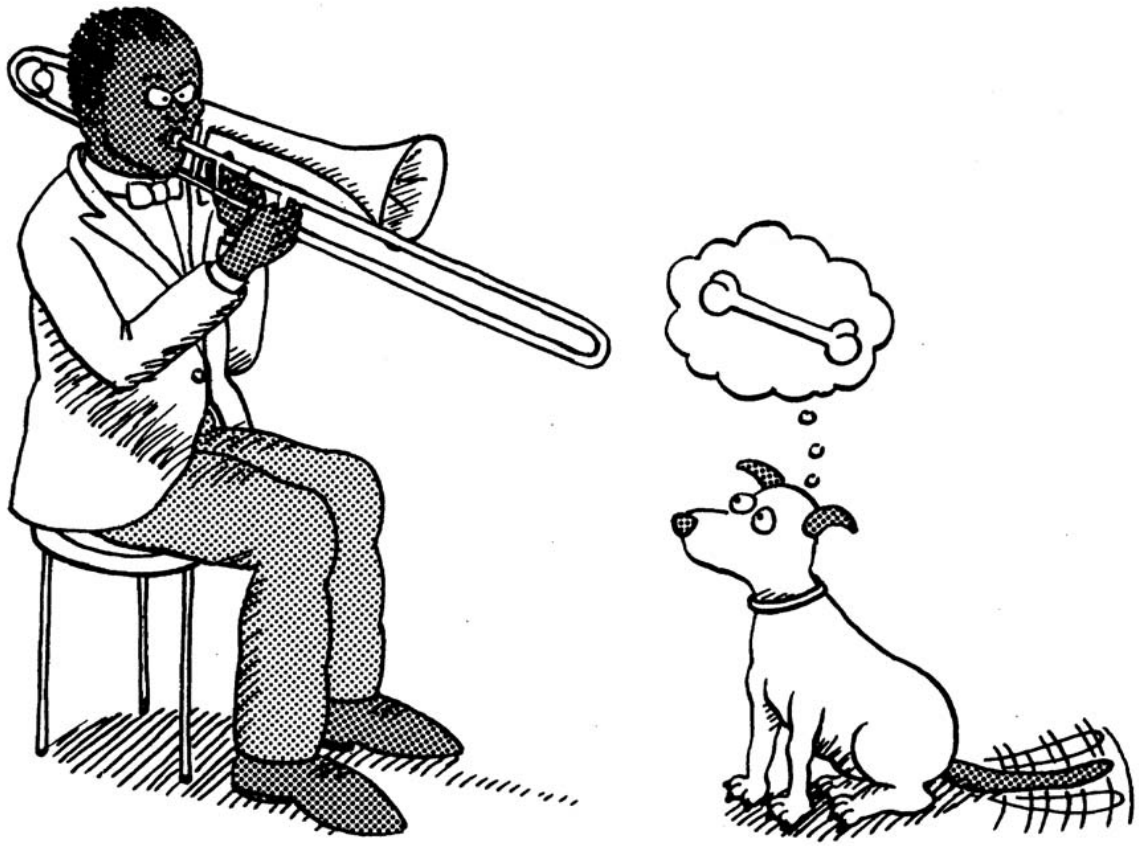
- Daniel Bernoulli (1738): St. Petersburg paradox
- Thurstone (1931): Individual choice, ordinal utility theory
  - Testing/constructing indifference curves
  - Various hypothetical choices between commodity bundles (coats&hats, shoes&hats, shoes&coats)
  - Criticized by Wallis&Friedman (1942): hypothetical
- Dresher/Flood(1950); Prisoners dilemma
  - 100 repetitions, payoffs in pennies
  - Criticized by Nash: multi-period instead of one-period
- Chamberlain (1948): Markets and competitive equilibrium using induced values

What Makes a Good Experiment?

- Capture important features of environment in a simple and controlled environment
- Experiment controls all elements of environment that influence choice
- Designed to test a specific set of hypotheses
- Randomization of subjects into treatment cells
  - Minimizes influence of uncontrolled variables on observed outcomes
  - Relies upon law of large numbers so concern about sample size
- Avoid confounds
  - Change only a single factor across treatments
  - Only change variables directly relevant to hypotheses being tested
- Control versus treatment comparisons

What Makes a Good Experiment?

- Designed to test a specific set of hypotheses
- One Main Goal of Experimental Studies:



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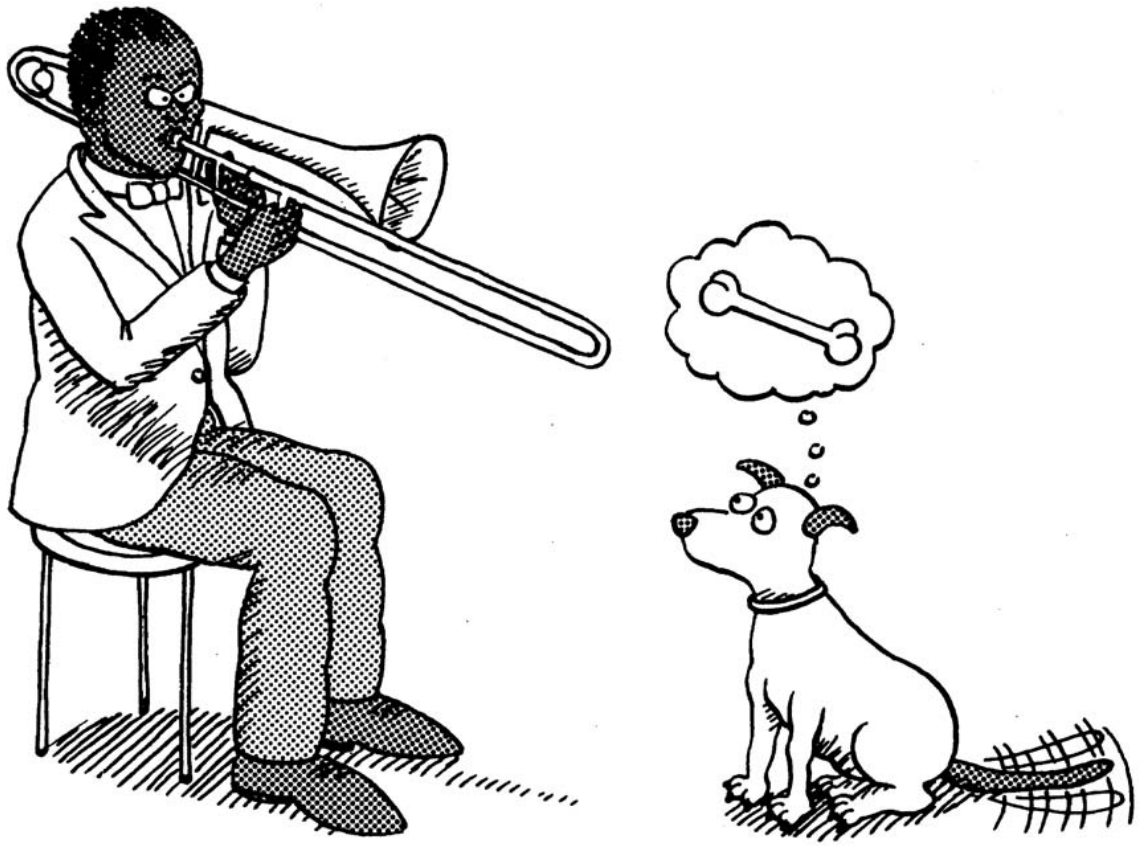
Comprehension of Task



Environmental Economics and Experiments

- Any environmental problem can be formulated as problem of public good provision
- Very active literature on voluntary provision of public goods
  - Donation mechanisms: seed money, gift exchange, lottery tickets
  - Voluntary provision of climate goods
  - Searching for mechanisms that reduce freeriding, induce cooperation

"There is an extraordinary amount of money available. The lack is of good ideas on how to get the basket under the apple tree." (The Economist, July 31st, 2004, p. 57)

Public Goods and the Challenge of Cooperation

- Climate policy and failure in Copenhagen
- Way to move forward to overcome free-riding
  - Negotiations involving all countries vs. smaller clubs (G8)
  - Lowering requirements to gain agreement by more countries
- Lack of enforcement mechanisms $\Rightarrow$ Voluntary action needed
- Challenges along two dimensions
  - Attract more members
    $=$ **Extensive margin**
  - Increase provision of public good from individual players
    $=$ **Intensive margin**

Voluntary Coalitions to Provide Public Goods

- **Coalition formation models**
  - Applied to international agreements (e.g., Hoel 1992, Barrett 1994, Carraro and Siniscalco 1993)
  - Pessimistic result:
    Large incentives to free-ride $\Rightarrow$ small coalitions
- Many theory extensions, but only few experimental tests
  - Burger and Kolstad (2008): coalition formation with discrete decision (contribute $\in \{0, 1\}$)

  $\Rightarrow$ Cannot explore intensive margin or trade-off between intensive and extensive margin

Voluntary Provision and Institution Formation

- Voluntary acceptance of institutions?
  - Kosfeld et al. (2009): Creation of sanctioning institutions possible, but less likely if some agents free-ride (Public good with punishment opportunities)
- How are rules of institution determined?
  - Exogenous:
    Decision about membership directly fixes required provision
  - Endogenous:
    Participants formulate rules, knowing the number of freeriders
  - For example: Provision requirements fixed by coalition size or endogenous?

In the next hour...

- Short theory of coalition formation and public goods
- Experimental test of coalition formation literature
  based on Dannenberg, Lange, and Sturm (2010)
  - Non-linear public good
  - Voluntary contribution mechanism (VCM) vs. coalition formation
  - Modesty may pay (Finus and Maus 2008) – Really?
    Less coalition effort $\Rightarrow$ larger coalition $\Rightarrow$ higher efficiency?
  - Minimum threshold game in VCM and coalition
- Conclusions and outlook

The Public Good Game

Payoff given by

$$w - q_i^2 + \alpha \sum_j q_j \qquad (\alpha = 10)$$

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Predicted contributions

- VCM predicts: $q_i = \alpha/2$
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Predicted payoff levels

- VCM predicts: $(2N-1)\alpha^2/4$
- Social optimum: $N^2\alpha^2/4$

A Modified Public Good Game

Suggesting minimum contributions

- Stage 1: Player j suggests $q_j^{\min}$
- Stage 2: Choice of q_i: binding $q_i \geq q^{\min} = \min_j q_j^{\min}$

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- Multiple equilibria
  - Stage 2: $q_i = \max[\alpha/2, q^{\min}]$
  - Stage 1: Coordination necessary. $q_j^{\min} = q^*$ as *one* equilibrium (weakly dominant strategies)
- Previous experimental evidence for linear public good game (Orzen 2009)
  - Possible convergence to social optimum

Coalition Formation I

The standard coalition formation game

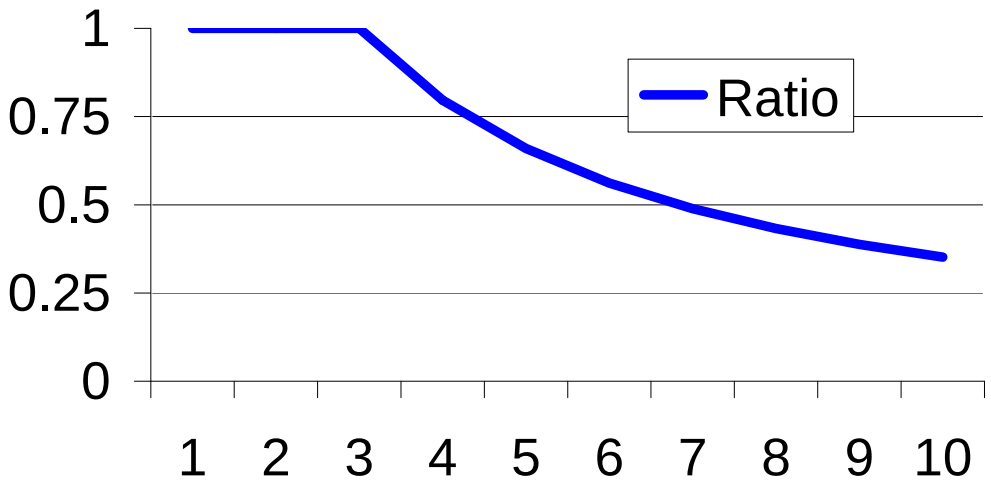
- Stage 1: Decision to enter the coalition S
- Stage 2: Coalition cooperates, but plays non-cooperatively against outsiders
- Equilibrium
  - Stage 2: coalition internalizes benefits of its members

  $\Rightarrow$ $q_i = k\alpha/2$ ($k = \#S$) if $i \in S$, and $q_i = \alpha/2$ if $i \notin S$
  - Stage 1: Well-known result: only $k = 3$ players form a coalition
  - Concept of internal and external stability

Coalition Formation II

Modified coalition formation game

- Modesty may pay! (Finus and Maus 2008)
  - Modified Stage 2: coalition provides less than optimal: e.g., $q_i(k) = (k\alpha/2)/2$
  - Less incentives to free-ride $\Rightarrow$ larger coalition predicted $k = 6$ or $k = 7$
  - Efficiency gains possible



Coalition Formation III

Modified coalition formation game with Minimum threshold

- Stage 1: Players enter or not
- Stage 2: Coalition members suggest minimum level $q_j^{\min}$
- Stage 3: Coalition players choose $q_i \geq q^{\min} = \min_j q_j^{\min}$, remaining players choose freely

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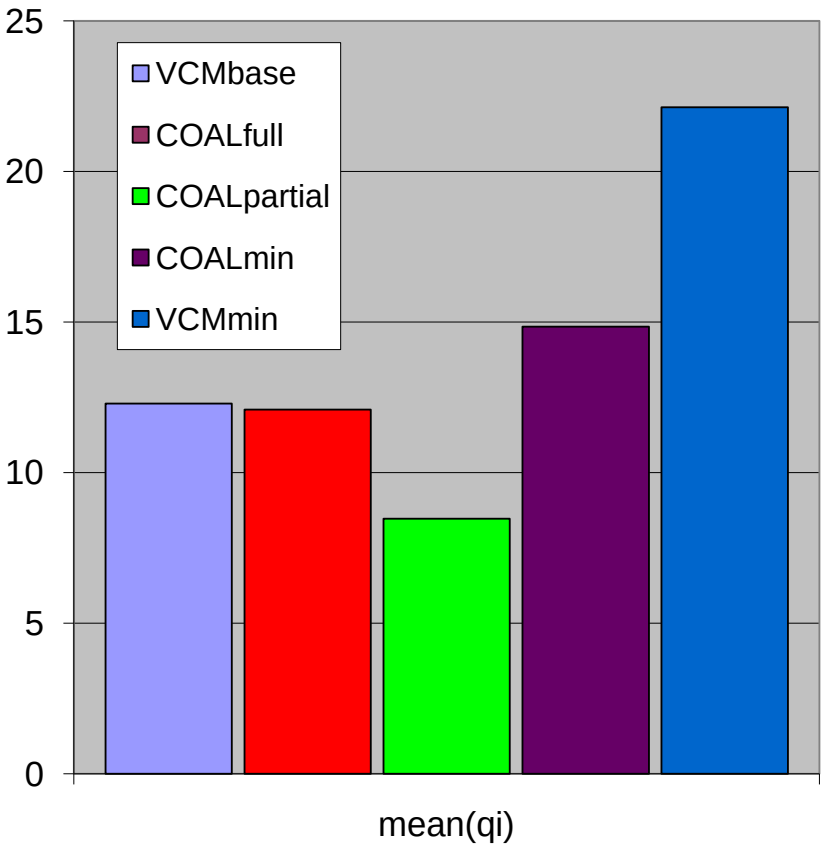
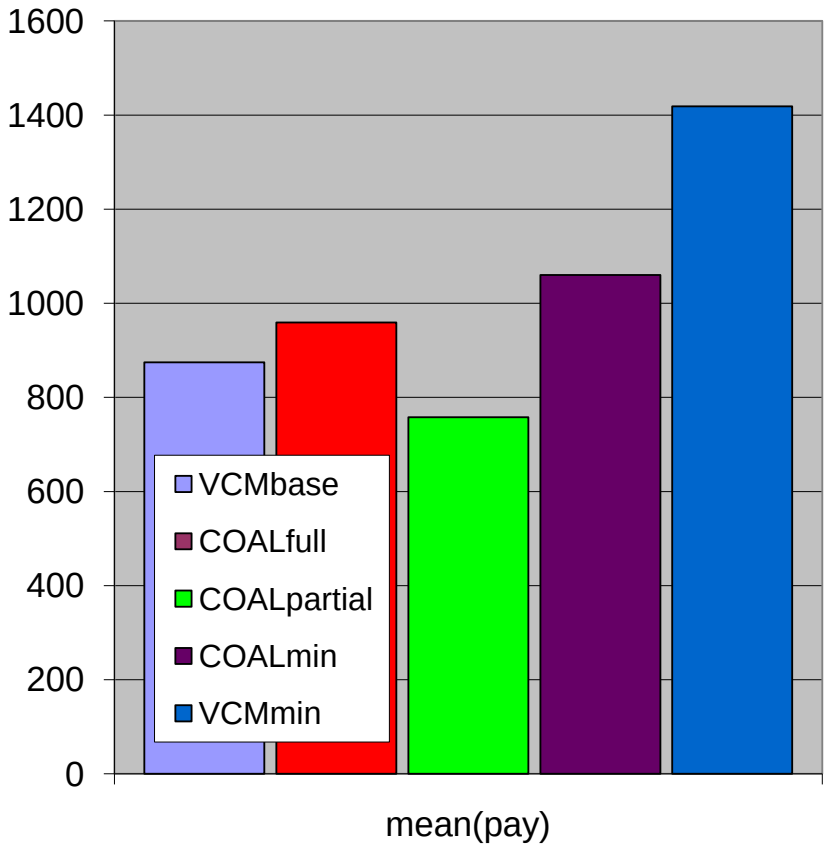
- Stage 1: Players enter or not
- Stage 2: Coalition members suggest minimum level $q_j^{\min}$
- Stage 3: Coalition players choose $q_i \geq q^{\min} = \min_j q_j^{\min}$, remaining players choose freely
- Multiple equilibria: trading-off coalition abatement and size
  - Corresponds to more sophisticated modesty pays: coalition with k members can be stabilized if in $k-1$ coalition sufficiently reduced efforts
  - Grand coalition could be sustained in equilibrium

Experimental Design

- **5 treatments**
  - VCMbase
  - COALfull, COALpartial, COALmin
  - VCMmin
- Experiments in Experimental Lab (MAXLAB), University of Magdeburg, using ZTree (Fischbacher 2007)
- 100 subjects in each treatment
- 10 periods, fixed group of 10 subjects
- Payments: one period at random plus 1EUR show-up fee
- Time: 60-90 minutes

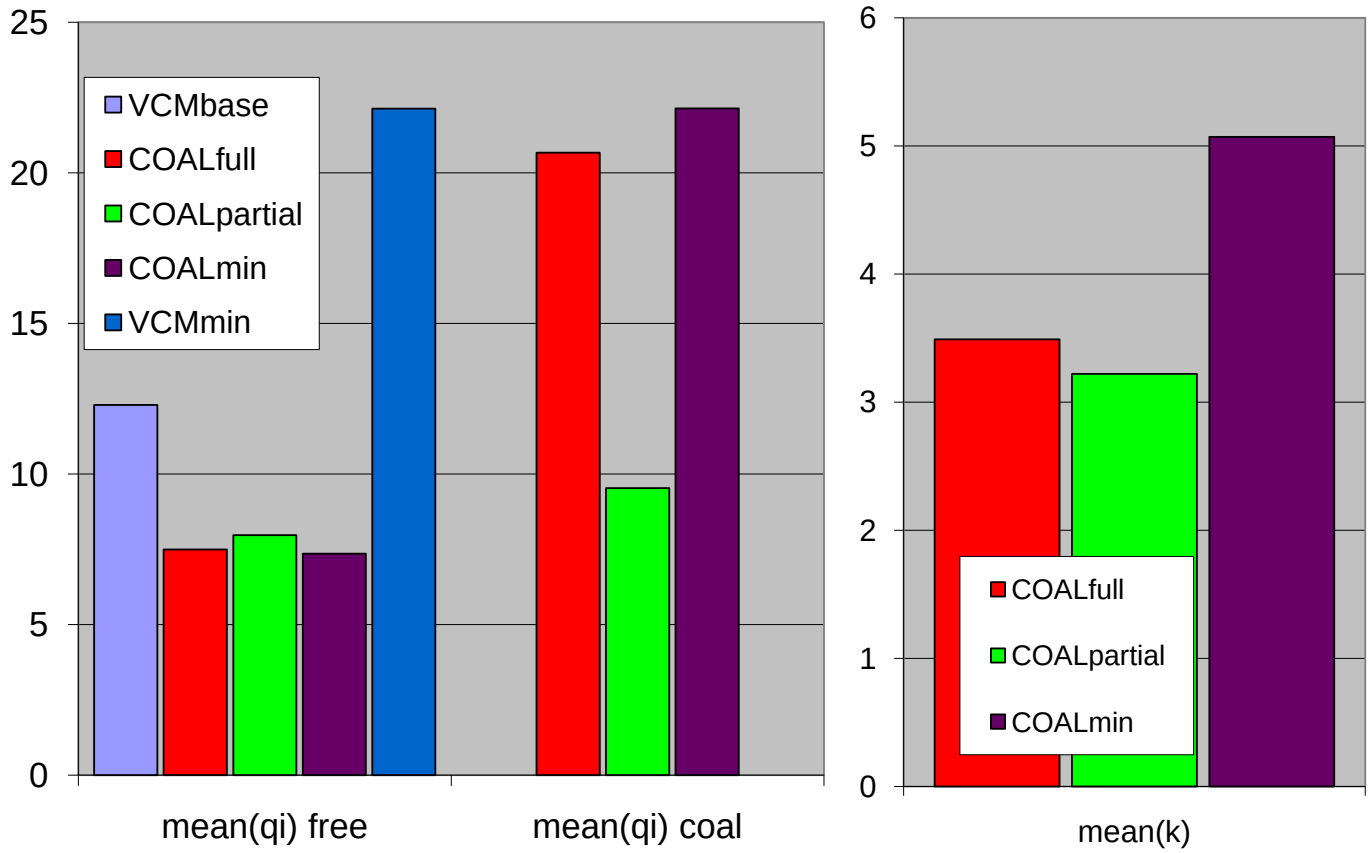
Experimental Result – Overview





- Coalition structure does *not* increase provision levels or payoffs
- Min-treatments generate larger provision levels

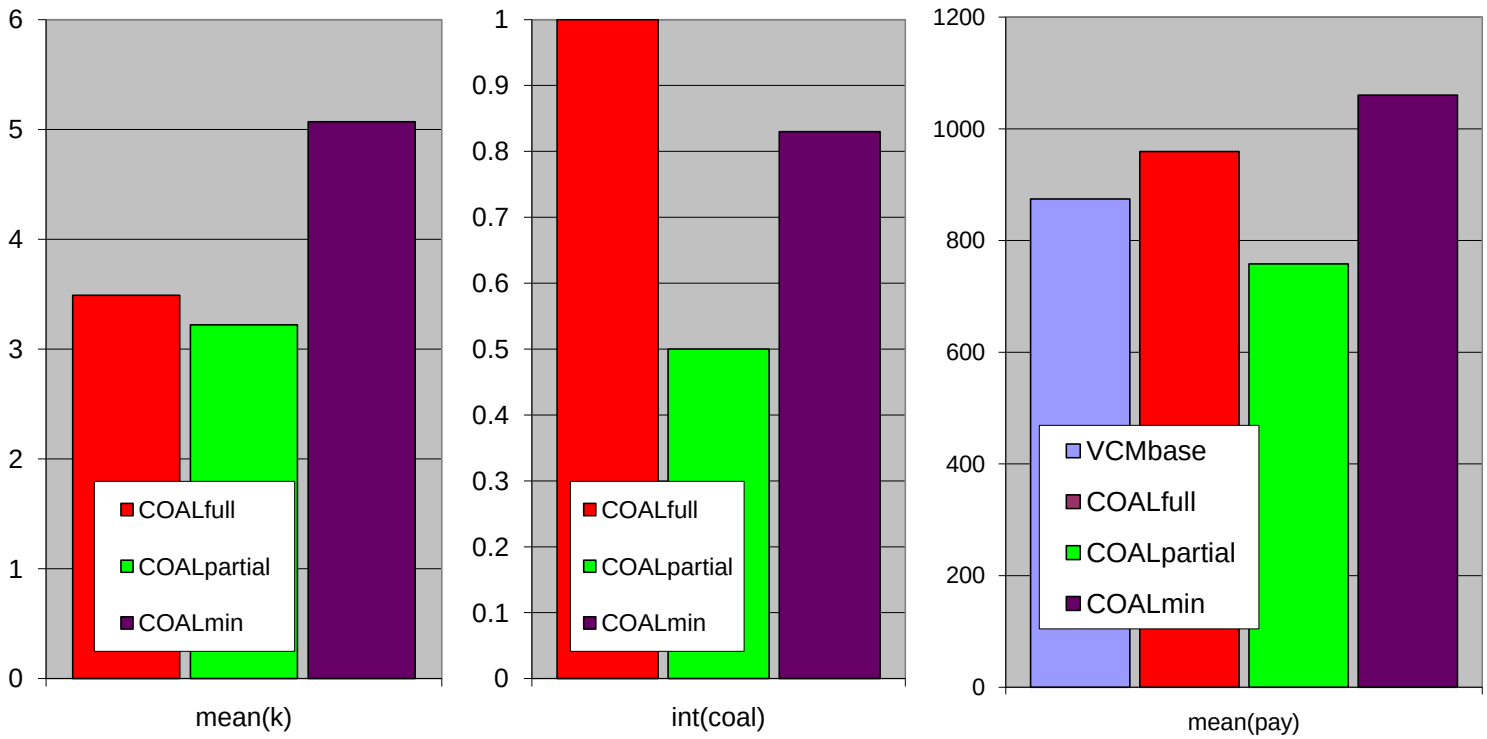
Experimental Results – Coalition Structure I



- Free-riders provide more than predicted $q_i = 5$, but less than 9 in coal-treatments
- Coalition not larger than $k = 3$ in COALfull and COALpartial

$\Rightarrow$ **Modesty does not pay!**

Experimental Results – Coalition Structure II



- COALmin allows coalition size to increase (1% significance)

$\Rightarrow$ **Coalition structure better accepted in min-treatments**

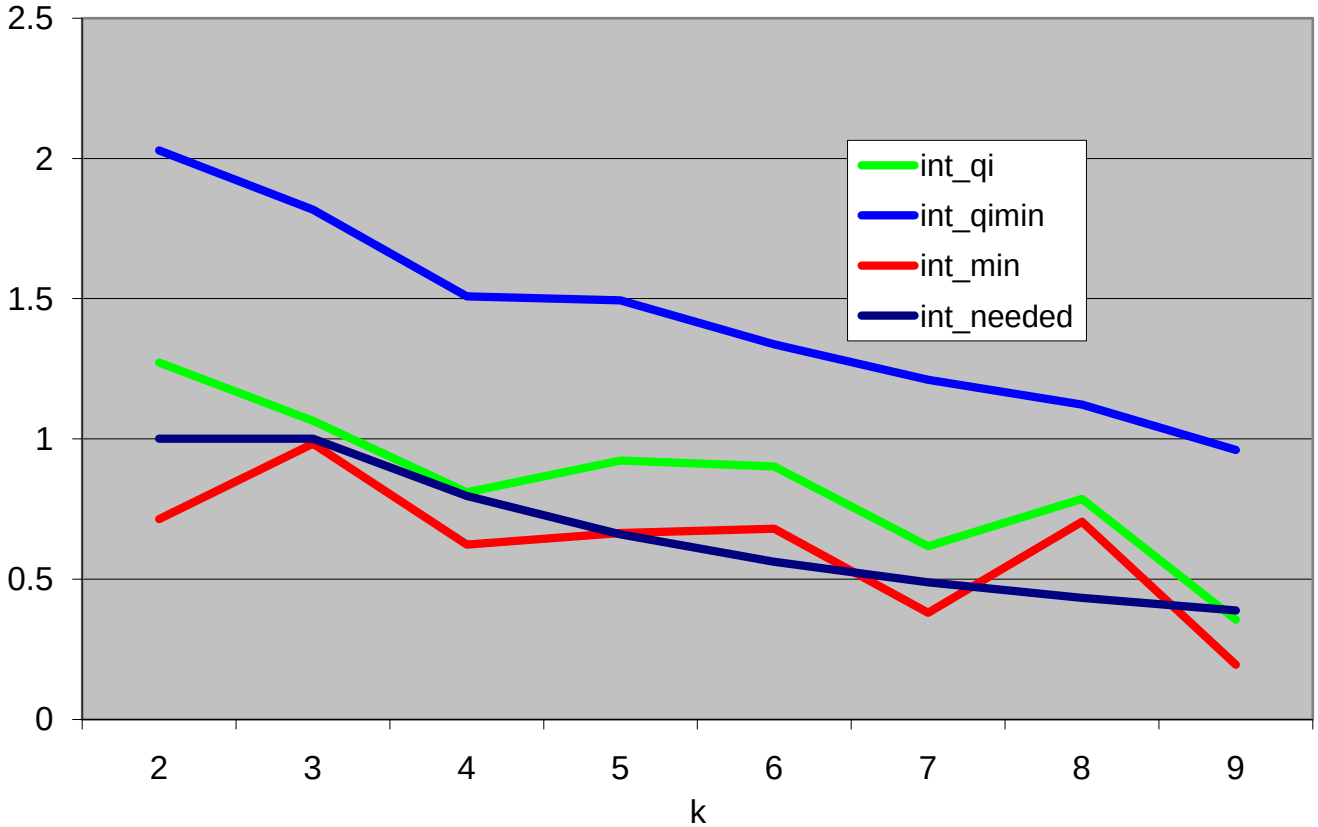
$\Rightarrow$ Gains along extensive *and* intensive margin

Experimental Results – The Role of Internalization Ratio

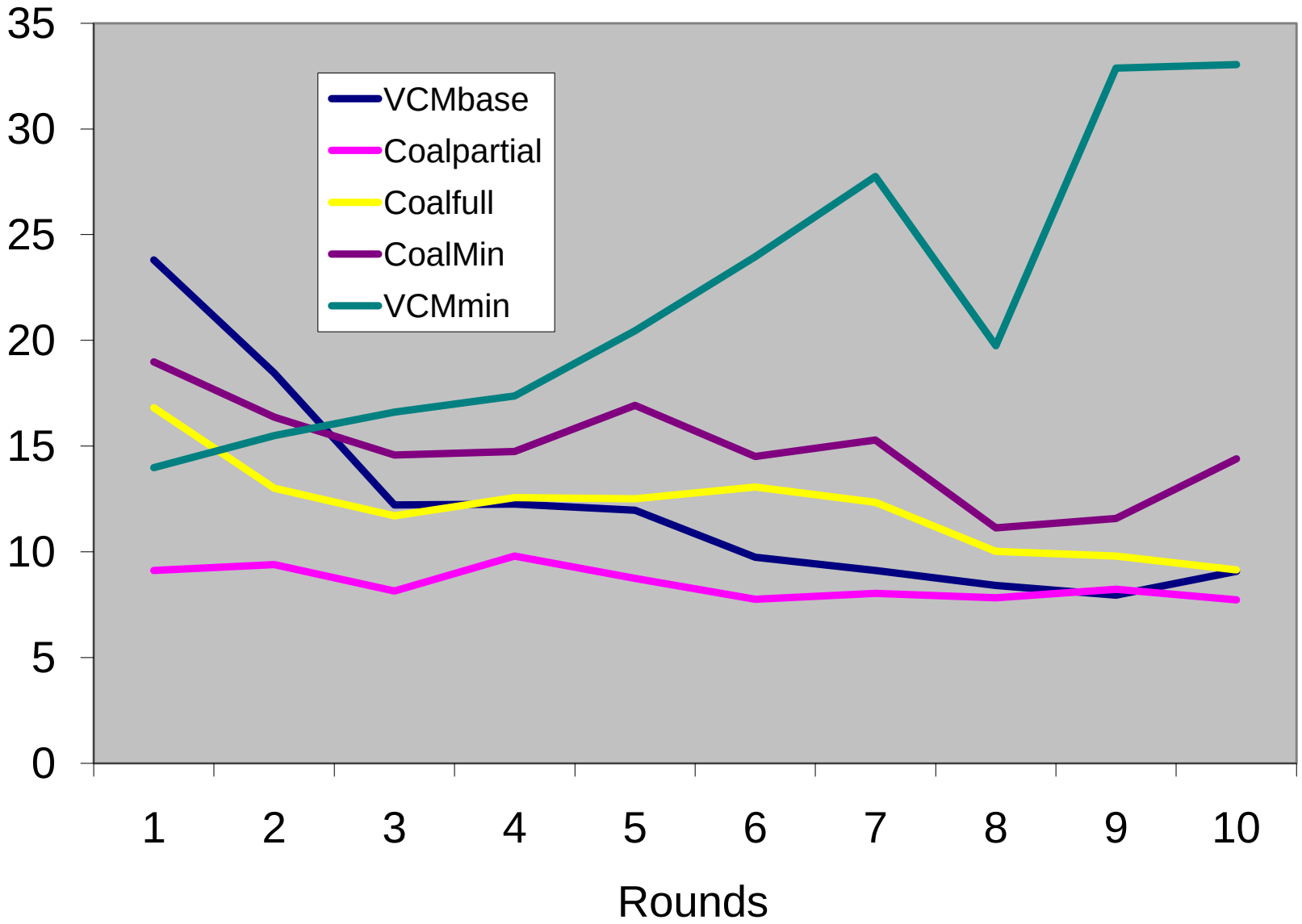
Internalization ratio $q^{\min}(k)/q^*(k)$:

- Determines freeriding incentives
- Exogenously fixed at 1.0 in COALfull and 0.5 in COALpartial
- On average 0.83 in COALmin, decreasing with periods *and* k

$\Rightarrow$ Reduction of free-riding incentives may increase coalition size



Experimental Results – A Closer Look at Time



Experimental Results – Contributions over Time

Individual qi	Provision qi Coeff.	Std.E.	Provision qi Coeff.	Std.E.	qi (last 5 per.) Coeff.	Std.E.
COALfull	-0.20	0.96	-2.42 *	1.34	2.02 **	1.03
COALpartial	-3.83 ***	0.73	-6.70 ***	1.07	-0.95	0.70
COALmin	2.55 ***	1.01	0.58	1.50	4.52 ***	1.37
VCMmin	9.83 ***	3.26	1.05	2.90	18.62 ***	4.48
per6_10			-6.88 ***	1.00		
per6_10_COALfull			4.44 ***	1.43		
per6_10_COALpartial			5.75 ***	1.08		
per6_10_COALmin			3.94 **	2.04		
per6_10_VCMmin			17.57 ***	3.80		
const	12.30 ***	0.61	15.74 ***	0.95	8.86 ***	0.59

- Random effect models confirm treatment differences
- Temporal changes significant
  - VCM: decline; more stable in COAL-treatments
  - COALfull dominates VCM in the long run
  - Increase in VCMmin-treatments

Coalition Formation – Decision to Enter

- Past behavior explains decision to be in coalition
- The larger k in the previous period, the larger is probability to be a member
- In COALmin, subjects are the less likely to join a coalition, the stricter the provision requirements, i.e. the larger the internalization ratio was in the previous period.
- Endogenous choice of provision requirements increases coalition size in COALmin

Adjusting the Minimum Proposals

- On average, subjects are adjusting the minimum proposals upwards over time
  - Upward trend smaller for players with large previous proposal
  - Pivotal players adjust upwards $\Rightarrow$ Binding minimum increasing
- 40% of contribution decisions in VCMmin and 65% of decisions in COALmin are exactly at the binding minimum level

$\Rightarrow$ Players minimum suggestions have large effect on the total provision level of the public good.

Conclusions – Coalition Formation

- Coalition structure leads to minor increases in provision above VCM
- Pessimistic predictions from literature confirmed
- Modesty does not pay! – unless combined with min-mechanism
- Minimum structure could lead to improved provision when agents have time to coordinate

$\Rightarrow$ Potential application in international agreements?

Conclusions and Outlook

- Trade-off between extensive and intensive margin fails when institution is exogenously fixed
- Endogenously determined requirements can yield gains along both extensive and intensive margin
- Smallest common denominator treatments (MIN) serve as beneficial coordination device
- Coalition structure inferior to direct modifications of VCM
- Application of minimum rule in international agreements?
  - Coordination over time
  - Uniform rule – How to adjust under heterogeneities?

What Can we Learn from Individual Behavior

- Experiments can clearly guide policy in observing individual responses to incentives
- Theory predictions can be tested
  - Assumes that Incentives are Right
  - Do potential social preferences extend to countries?
- Normative implications of observational science...