Macroeconomics: A Survey of Laboratory Research

Chapter for the *Handbook of Experimental Economics*, Vol. 2

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How to Characterize Experimental Macroeconomics?

- A large number of subjects? No. Most modern macroeconomic models presume a representative agent and do not address aggregation issues. Approximately competitive outcomes can be achieved with small numbers of subjects (e.g., Duffy et al. 2011).
- In practice, experimental macroeconomics is not distinct from microeconomic laboratory experiments, there is just a different focus or interpretation.
- A macroeconomic experiment as *one that examines the predictions of a macroeconomic model or its assumptions or is framed in the language of macroeconomics*.
- Novel macroeconomic experimental methodological innovations: implementation of infinite horizons and discounting, overlapping generations, the representative agent assumption, analysis of the convergence of time series, learning-to-forecast versus learning-to-optimize.

Why Do Macroeconomic Experiments?

- No field data available.
- Causal inference is difficult outside of the laboratory.
- In environments with multiple equilibria, equilibrium selection is ultimately an empirical question (Lucas (1986).
- Want to understand the role of institutions/policies and real-world/field experiments are not possible/ethical.
- Want to check the robustness of model predictions to play by subjecs who may be boundedly rational, non-risk neutral, etc.

Chapter Organization

1. Microfoundations
2. Coordination Problems
3. Field Topics
4. Macroeconomic Policy

- Parts of this chapter update *Handbook of Experimental Economics* chapters on "Coordination Problems" (Ochs), "Asset Markets" (Sunder) and "Individual Decision Making" (Camerer), though here the focus is on models primarily of interest to macroeconomists.
- The chapter draws on earlier surveys of macroeconomic experiments by Duffy (1998, 2008) and Ricciuti (2008).

1. Microfoundations

Modern macroeconomic models have explicit *microfoundations*. These can be tested in the laboratory:

1. Intertemporal optimization (consumption/savings decisions): Is consumption smoothing observed? Is there a precautionary savings motive?
2. Time (in)consistency of intertemporal decisions: exponential vs. hyperbolic discounters or neither?
3. Expectation formation: rational or adaptive or neither?

What about aggregation?

Despite the Sonnenshein-Debreu-Mantel result–that the system of excess demand functions characterizing an economy with many agents need not correspond to the demands of any individuals in that economy–macroeconomists frequently impose the Representative Agent (RA) assumption (Fisher 1997).

Given this state of affairs, macro-experimentalists have pursued several approaches:

- Take the RA assumption seriously and conduct individual decision-making experiments, e.g., on intertemporal decision-making.
- The RA assumption implies that there are no coordination problems and no trade. Those assumptions can be tested in the laboratory.
- Introduce an aggregation mechanism, e.g., double auction or call markets to obtain market-clearing prices and quantities.
- Some macro models (e.g. search-theoretic or overlapping generations) do have heterogeneous player types and aggregation mechanisms that are testable in the lab.

Intertemporal Optimization: Issues and Methods

- Can individuals solve a stochastic, dynamic intertemporal optimization problem?

$$\max_{c_t} E_t \sum_{t=0}^{T} \delta^t u(c_t)$$

subject to:

$$c_t + x_t \leq \omega_t$$

where c_t is time t consumption, $u(\cdot)$ is a concave utility function, δ is the period discount factor, x_t represents time t savings and ω_t is the household's wealth.

- Methodologically, laboratory studies have typically:
  - used both finite and indefinite $T = \infty$ horizons.
  - have induced preferences or allowed home-grown preferences.
  - have used exogenous rates of return on savings, R.
  - have wealth evolve according to $\omega_{t+1} = R(\omega_t - c_t) + y_{t+1}$, with y being a stochastic income process (or set to zero).

Intertemporal Optimization: Main Findings

- Under-saving relative to the (conditionally) optimal path. Consumption "binge-ing" More
- Consumption varies with immediate past income realizations. (Hey and Dardanoni (1988)).
- Some improvement in the direction of the optimal consumption/savings plan with social (intergenerational) learning (Ballinger et al. 2003, Brown et al. 2009).
- Trading an asset as an aid to smoothing consumption also helps (Crockett and Duffy 2010).
- Comparative static implications find some support (Carbone and Hey (2004)). More
- Use of double auction market to allocate capital does better than an individual in the role of a social planner. (Lei and Noussair (2002)). More
- Internal habit formation may induce agents to save more early and get them closer to the optimal path (Brown et al. (2009))

Discounting and Infinite Horizons: Methods

- Most macroeconomic models assume infinite horizons. Bequest motives are assumed operative so individuals are viewed as part of a family dynasty.
- Exponential discounting is implemented by having a constant probability δ that a sequence of decision rounds continues with one more round (following Roth and Murnighan 1978). By contrast with game theory experiments, in macro-experiments the value of δ often *matters* for the value of predicted outcomes, e.g., the price of an asset depends on the value of δ.
- In practice, it is good to 1) have multiple indefinite sequences in a session (so as to properly induce discounting of payoffs) and 2) recruit subjects for enough time to allow the experiment to end naturally and 3) Use a transparent randomization device.

Discounting: Exponential Findings

- Elicitation of rates of time preference (discount rates) is achieved by asking subjects to choose between pairs of delayed monetary rewards, e.g., amount $\$D$ in 2 days or $D(1+r)$, in $2+t$ days, where $r > 0$ is fixed and t is incrementally increased, $t = 1, 2, ..$ Any subject with a positive discount rate will eventually switch.
- The time t^* at which a subject permanently switches from the larger amount, $D(1+r)$ to the smaller amount, D, is used to solve for their discount factor $\delta_i : \delta_i^{t^*} = 1/(1+r)$ (assumes linear utility from money). Similar to methods for eliciting risk aversion.
- No consistent estimates of discount rates across many studies (Frederick et al. (*JEL* 2002)).
- Time preferences cannot really be elicited apart from risk preferences (above we assumed risk-neutrality). See Anderson et al. (2008).

Discounting: Exponential of Hyperbolic?

Quasi-hyperbolic discounting: Representative agent maximizes

$$u(c_t) + \beta \sum_{i=1}^{T} \delta^i u(c_{t+i}),$$

where $\beta \leq 1$ characterizes the agent's bias–for–the–present (exponential discounting has $\beta = 1$).

Experimental evidence on this form of discounting is mixed but evidence for exponential discounting appears to be soundly rejected.

E.g. Benhabib et al (2008) and Coller et al. (2006) find that a small fixed premium attached to immediate rewards, can reconcile much of the variation in discount rates between the present and the future and between different future rewards. This premium does not vary with the amount of future rewards (Benhabib et al.) and may simply reflect transaction/credibility costs associated with receiving delayed rewards (Coller et al.).

Expectation Formation: Methods

- In modern, self-referential macroeconomic models, expectations of future endogenous variables x, play a critical role in the determination of current values of endogenous variables, e.g., $x_t = f(x^e_{t+1})$.
- Agents are assumed to have rational, (model-consistent) expectations.
- Early experiments asked whether expectations are rational in the sense that forecast errors are not systematic; researchers used exogenous data generating processes: Schmalensee (1976) or Dwyer et al. (1993). Later tests of rational expectations used data determined by the choices of subjects themselves: Williams (1987), Smith et al. (1988). Expectations are found to display systematic errors, inconsistent with REE.
- If the environment is sufficiently stationary, REE can be learned if the error feedback is negative (as in many commodity markets) but learning REE is less likely with positive feedback (as in many financial markets)– Heemeijer et al. (2009).

Learning to Forecast vs. Learning to Optimize

- Marimon and Sunder (1993, 1994) pioneered a "learning-to-forecast" design where subjects only provide forecasts of expected future (date $t+1$) endogenous variables. These are entered into the macroeconomic model to determine subjects' optimal, date t choices. These choices together with market clearing conditions determine the realizations of the variables subjects were forecasting. Subjects are rewarded on the basis of forecast accuracy alone; the macroecomic model is a "black box."
- LtF used to study, e.g., how central banks may manage private sector expectations. In particular, does Taylor's principle, that the central bank adjust nominal interest rates more than proportionally to changes in inflation work to stabilize inflation expectations? Yes - see: Pfajfar and Zakelj (2011), Assenza et al. (2011)). More
- Bao et al. (2012) compare LtF and learning to optimize designs; LtF does better (but involves computer assistance!)

Boundedly Rational Expectation Formation

Some macroeconomists have replaced the rational expectations assumption with boundedly rational expectation formation processes that converge to rational expectations in the limit, following many repetitions:

1. Step-level or level-k reasoning imagines that players are heterogeneous in their abilities to iterate their way toward a rational expectations equilibrium. The lowest type, L_0, make purely random choices. The next higher level L_1, players play "best responses" to the behavior of the L_0 types. Level L_2 players play "best responses" to the L_1 types, etc. This is reminiscent of Keynes's (1936) comparison of financial market investor's expectations to newspaper beauty contests.
2. Adaptive (recursive least squares or gradient) learning approaches to expectation formation, e.g., Sargent (1993, 1999) Evans and Honkapohja (2001) imagine that agents behave as though they were econometricians, forming expectations using the historical data record, and updating

Boundedly Rational Expectation Formation: Findings

- Step-level analyses of behavior in the "beauty contest" game (e.g., Nagel (1995)) provides both evidence against rational expectations in the short-run and in favor of heuristic, step-level reasoning. More
- Hommes et al. (2008, 2005) adopt a learning to forecast approach to study price formation in the Cobweb model. They vary the stability of the cobweb model under the assumption of naive expectations and find that subjects learn the rational expectations price level regardless of the stability condition, but there is higher than rational variance (excess volatility) as the model is made more unstable. More
- Adam (2007) shows in the context of a New Keynesian model that subjects may coordinate on non-rational expectations, "restricted perceptions" equilibria which involve miss-specified forecast rules that are Muthian (model–consistent, no systematic errors) but not rational (wrong forecasting model).

2. Coordination Problems

Why are these of interest to macroeconomists?

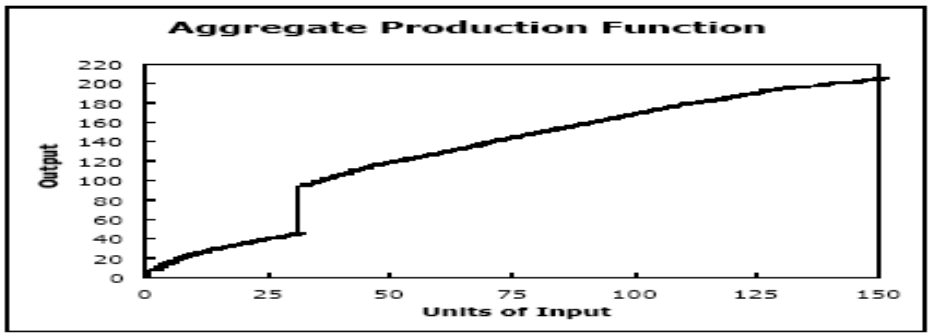
- Fallacies of composition - individual pursuit of self-interest may have adverse aggregate consequences.
- Representative agent assumption may mask considerable heterogeneity in behavior, which may itself present a coordination problem, e.g., if some individuals are rational and far-sighted while others are myopic, how to behave (e.g. ride a bubble or pop it?)
- Even with perfectly rational agents, macroeconomic models often give rise to multiple equilibria that theory cannot resolve. In such situations, Lucas (1986) famously proposed putting people in the lab and "seeing what they do."

Coordination Problems: Models and Potential Solutions

1. Poverty traps: Escape from an inefficient low growth to a high growth equilibrium?
2. Bank runs: Transition from a efficient equilibrium involving financial intermediation to an inefficient panic equilibrium?
3. Mechanisms for solving coordination problems: Nonfundamentals - sunspots (a.k.a. animal spirits, self-fulfilling prophecies).
4. Mechanisms for solving coordination problems: Fundamentals - the global game refinement.

Poverty Traps

- Lei and Noussair (2003) add a non-convexity in production to the one-sector optimal growth model yielding two Pareto rankable stable, stationary levels for the capital stock (and output) $\overline{k}_l < k^* < \overline{k}_h$.



- Subjects start above or below k^* and in a decentralized setting or as social planners. They find that the poverty trap is the attractor in the decentralized setting while social planners coordinate on capital stocks near k^* or to the golden-rule level that maximally equates consumption in every period.
- Capra et al. start subjects below k^* and examine whether voting and/or communication aids in escape from poverty traps. More

Bank Runs

- Diamond and Dybvig's (1983) bank run model has an efficient separating equilibria, where patient types wait to withdraw funds and impatient types withdraw early and an inefficient pooling (panic) equilibrium where both types withdraw early and the bank must liquidate its long-term investments.
- Garratt and Keister (2009) study the following bank-run game with 5 depositors and 1-3 withdrawal opportunities:

No. of Early Withdrawal Requests	Amount Each Early Requester Receives	Payment to Each Who Don't Withdraw
0	n/a	\$1.50
1	\$1	\$1.50
2	\$1	\$1.50
3	\$1	\$0
4	\$0.75	\$0
5	\$0.60	n/a

- Panic equilibrium only arise if there are liquidity shocks: 1 (unknown) subject is randomly forced to withdraw early.

Sunspots

- Are non-fundamental variables that may serve as a coordinating device. The explanation of bank run equilibria in Diamond and Dybvig's (1983) bank-run model relies on sunspots. Keynes (1936), Ackerlof and Shiller (2009) refer instead to 'animal spirits'.
- Marimon et al. (1993) hoped subjects might use a blinking light that alternated in color between red and yellow as a mechanism for coordinating price forecasts on a cyclic equilibrium in an OG economy. When correlation with fundamental shocks was removed, subjects essentially ignored the sunspot variable realizations and coordinated on a stationary outcome.
- Duffy and Fisher (2005) found that subjects would coordinate on spurious public forecasts for prices (determined by flipping a coin) provided that no other information was available–when prices were determined in a highly centralized "call" market. However, if prices were determined in a double auction, the efficacy of the sunspot variable as a coordination device was much reduced. More

Global Game Refinement: Fundamentals Matter

- Morris and Shin (1998, 2001) argue that indeterminacies arise from assuming that economic fundamentals are common knowledge and that individuals are certain of the behavior of others in equilibrium.
- Relaxing these assumptions, e.g., by introducing some uncertainty about fundamentals, can remove the multiplicity, á la the Carlsson and van Damme's (1993) global game approach for 2×2 games. This proposed refinement has been tested experimentally by Heinemann et al. (2004) in the context of a $2 \times n$ player speculative currency attack game with multiple equilibria.
- Heinemann et al. report that subjects play entry games of complete information similarly to the way they play the related global game of incomplete information. Consistent with the global game refinement, they adopt threshold strategies attacking only when fundamentals are sufficiently weak and not attacking otherwise.

3. Sectoral Macroeconomics: Monetary Economics

Money's three roles have been studied experimentally:

- As a store of value. Money may have value in use even with a finite horizon (McCabe (1989)). Money may serve as an intertemporal store of value among overlapping generations of agents (with no other means of savings) and low (as opposed to explosive or high) inflationary equilibria are typically chosen by subjects. Lim et al. (1994), Marimon and Sunder (1993, 1994 1995), Bernasconi and Kirchkamp (2000), Camera et al. (2003), Deck et al. (2006).
- As a medium of exchange. Low cost objects emerge as media of exchange in a search-theoretic models where there is an absence of double-coincidence of wants. Brown (1996), Duffy and Ochs (1999, 2002). More
- As a unit of account. Individuals are subject to money illusion, thinking in nominal rather than real terms. (Diamond et al. (1997), Fehr and Tyran (2001, 2007, 2008), Petersen and Winn (2011). More

3. Sectoral Macroeconomics: Labor Economics

- Search theoretic models - support for comparative static implications of optimal job search (Braunstein and Schotter (1981, 1982) for an infinite horizon, Cox and Oaxaca (1989, 1992) Sonnemans (1998) for a finite horizon.
- Labor-leisure tradeoffs: wage increases have both income and substitution effects on hours worked. Battalio et al. (1981) and Dickinson (1999) report evidence that the (compensated) elasticity of labor supply to a wage increase is positive, in accordance with the assumption made in most business cycle models.
- Efficiency wage theory: Higher than market wages are reciprocated with high effort. Ernst Fehr and associates show in several papers that if workers outnumber firms/positions, and firms offer high wages, reciprocity considerations can lead to high effort levels exerted by subjects playing the role of workers.

Gift Exchange Game: Incompleteness of Labor Contracts

- Fehr, Kirchsteiger and Riedl (1993, 1998), Gächter and Fehr (2002). More
- Subjects as firms or workers, # firms $<$ # workers.
- Firms can hire at most one worker and move first, posting wage offers $w \in [\underline{w}, \overline{w}]$. If a worker accepts a wage offer, they then choose an effort level $e \in [\underline{e}\ \overline{e}]$.
- Payoffs to workers are $w - c(e)$, where $c(e)$ is a convex cost of effort function. Payoffs to firms are $(v - w)e$ where v is the firm's redemption value. All payoff functions, wage and cost of effort schedules were public knowledge.
- Interactions are repeated, but anonymous, (so one-shot?) The subgame perfect equilibrium prediction is that workers will choose the lowest possible effort level $\underline{e}$ and recognizing this, firms will offer the lowest possible wage $\underline{w}$.
- Experimental finding is that high wage offers lead to high effort: Players have preferences for fairness/reciprocity.

3. Sectoral Macroeconomics: International

- Trade theory
- Noussair et al. (1995) test the law of comparative advantage in a model with two countries, 1 and 2 with two final goods, Y and Z. The countries differ only in their production technologies, which (in the Ricardian version) involve only labor input L_i from country $i = 1, 2$.

$$\begin{array}{lll} \text{Country 1} & Y_1 = 3L_1 & Z_1 = L_1 \\ \text{Country 2} & Y_2 = L_2, & Z_2 = 2L_2 \end{array}$$

- Labor is immobile across countries but trade in goods is possible.
- Six markets - two internal labor markets and four final goods markets are implemented using double auctions.
- The comparative advantage prediction, wherein country 1 specializes in production of good Y and country 2 specializes in production of good Z is confirmed.

International Finance

- Purchasing power parity and exchange rate determination have been studied experimentally using two-country models.
- Noussair et al. (1997) use a two country model with two different money supplies, introduced via cash-in-advance constraints. They study whether purchasing power parity holds.
- Fisher (2001, 2005) provides a simpler framework in which to address purchasing power parity as well as (un)covered interest parity.
- Arifovic (1996) Considers a two-county overlapping generations models where there are no cash-in-advance constraints and the monies of the two countries are perfect substitutes for one another. She addresses the indeterminacy of the exchange rate issue, and finds that exchange rates do appear to converge, but fluctuations persist, consistent with what is seen in actual time series data.

The Big Picture: Multi-sectoral Systems

Lian and Plott (*ET* 1998) consider an environment with double auction markets, where there are workers and firms, two goods (X,Y), money and bonds, workers seek to maximize preferences over (X,Y) and sell labor Y to firms for money; firms seek to maximize output of X using labor input, which they then sell for money. Generally, efficiency is high. A novelty is that such an exercise can be performed at all! More

Macroeconomic Policy Issues

- Ricardian Equivalence: Are government bonds net wealth (Barro 1974)? Or do rational agents anticipate that deficits today imply greater taxes on their children tomorrow, and thus a need to bestow larger bequests?
- Cadsby and Frank (1991) use an overlapping generations model with dynastic utility and consider the choice of bequest amount from old to young agents.
- They find that bequests are close to optimal, but changes in bequests do not fully offset changes in government debt, so that the Ricardian prediction does not hold perfectly. More

Commitment versus Discretion

- Peasant-dictator games: Peasants decide whether to consume or plant beans. Planting beans yields a harvest of more beans, which is subject to taxation by the dictator (immediate consumption is not).
- Van Huyck et al. (2001) show that a dictator's reputation for low taxes in a repeated game setting serves as a poor substitute for commitment (pre-announced tax rates), but improves upon pure discretion, choosing tax rates after beans are planted. More
- Arifovic and Sargent (2003) induce a Kydland-Prescott environment with an expectational Phillips curve and show than subjects in the role of the central bank can often learn their way to implementing an optimal Ramsey (commitment) equilibrium involving zero inflation.

Monetary and Fiscal Policies

- Monetary Policy Decisions: Blinder and Morgan (2005, 2007, 2008) and Lombardelli et al. (2005) show that the decisions of monetary policy *committees* outperform those of individuals. Engle-Warnick and Turdaliev (2010) show that subjects learn to control inflation/output in a manner that resembles a Taylor rule.
- Bernasconi et al. (2006) explore how subjects form expectations about fiscal variables, e.g., government expenditure levels and tax revenues. Answer: Very adaptively, with great weight placed on recent forecast errors.
- Riedl and van Winden (2001, 2007) explore government tax policies concerning the financing of unemployment benefits. Specifically, they consider the impact on unemployment of a constant unemployment benefits tax that, in equilibrium results in a balanced budget, versus a dynamic tax policy that only gradually closes any budget deficit. They find that the dynamic policy leads to a worse outcome than does the stable

Political Economy: Redistributive Policies

- van der Hiejeden et a. (1998) and Offerman et al. (2001) hypothesize that social security systems involving transfers from young to old might be voluntarily sustained by a grim trigger strategy in which a failure of any young generation to transfer funds to the old would revert to a perpetual punishment of no further transfers.

	Choice of Player P_{t+1}	
Choice of Player P_t	A	B
A	50	15
B	70	30

- They find that some voluntary transfers from young to old do occur, but are well below the optimum, (suggesting the need for compuslory social security systems).

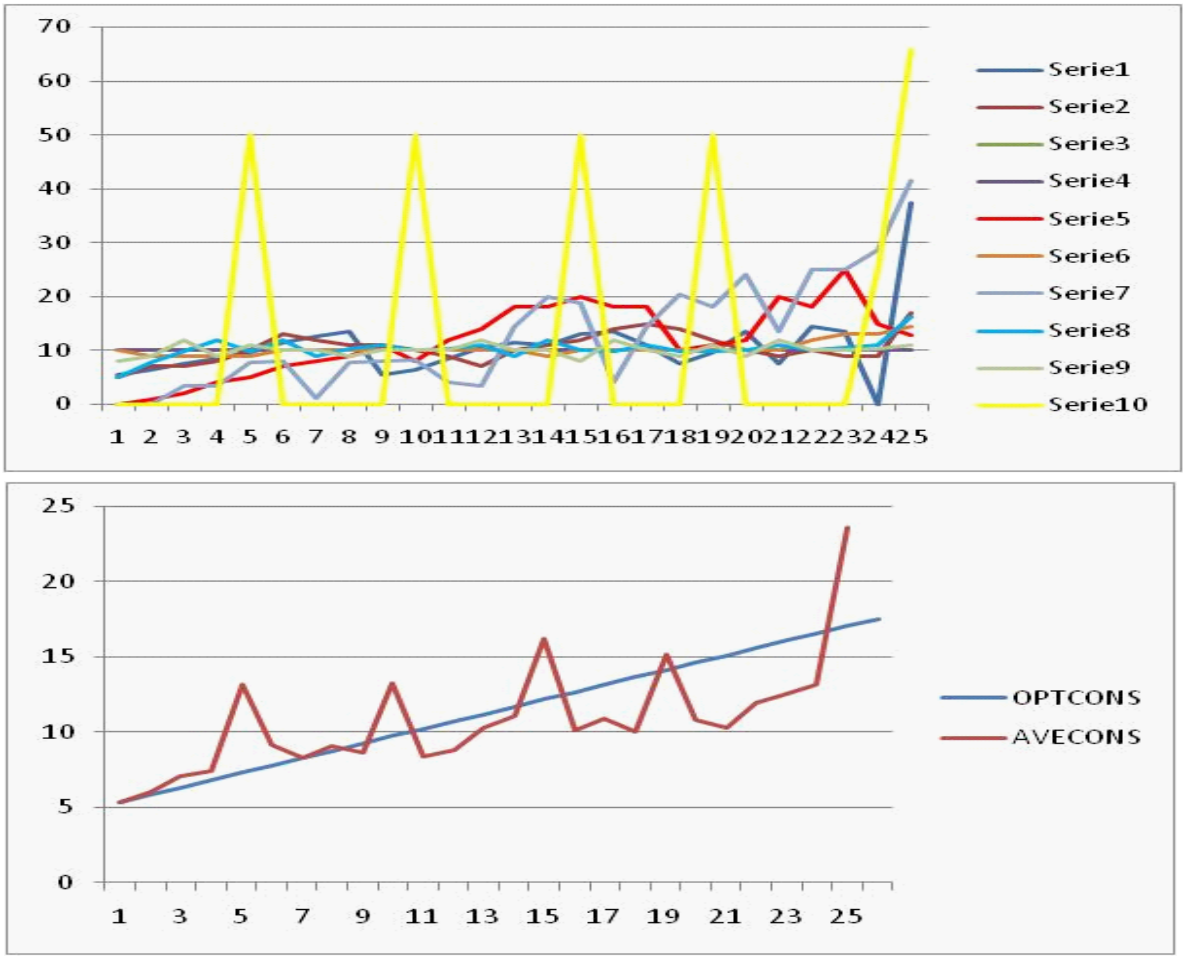
What is Left to Do?

- Many things!!! Here are just a few ideas for macro-experiments:
- Endogenous growth models, e.g. AK models, or models with knowledge externalities due to human capital accumulation (Romer)
- Political economy models of deficits: is there a political business cycle? (Alesina)
- Sources of sticky price adjustment: is it learning/bounded rationality or costly information updating or sticky information (Mankiw and Reis))?
- Search and matching model of the labor market with equilibrium unemployment (Mortensen and Pissarides).
- Monetary policy rules: which is most effective at controlling inflation: money supply or interest rate rules? (Friedman or Taylor rules).
- Social security: welfare consequences of pay-as-you-go versus fully funded systems.

Some Remaining Methodological Issues

- Combine "learning-to-forecast" with "learning-to-optimize" designs, e.g., a household consists of a forecaster and an allocator who uses his partner's forecast to make an allocation decision for the team.
- Induce preferences or allow homegrown preferences? e.g., with regard to consumption.
- Make better use of the lab in understanding the role of aggregate uncertainty; in field data, the (hard-to-identify) shocks are already in the data, but in the lab we can consider a variety of different aggregate shocks and ask what kinds of affects they have on behavior.
- Make better use of the internet; put together panels of subjects and study their intertemporal decision-making in a truely intertemporal manner, e.g., daily or weekly.
- Does population size, demographics, experience matter?
- How to test recursive formulations?: Elicit from subjects a policy function or have them make choices sequentially?

Lifecycle Consumption Relative to the Optimal Path



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Hey and Carbone (2004)

- Treatment variables were $p = \Pr$[staying employed] $q = \Pr$[becoming employed], R and the ratio of employed to unemployed income.
- They considered two values of each, one high and one low, and examined how consumption changed in response to changes in these treatment variables relative to the changes predicted by the optimal consumption function (again numerically computed).

Change (Δ) in treatment variable (from low value to high value)	Unemployed		Employed	
	Optimal	Actual	Optimal	Actual
Δp (Pr. remaining employed)	5.03	23.64	14.57	39.89
Δq (Pr. becoming employed)	14.73	-1.08	5.68	0.15
Δ ratio high-low income	0.25	0.24	0.43	0.76

Average Change in Consumption in Response to Parameter Changes and Conditional on Employment Status, taken from Carbone and Hey (2004,Table 5).

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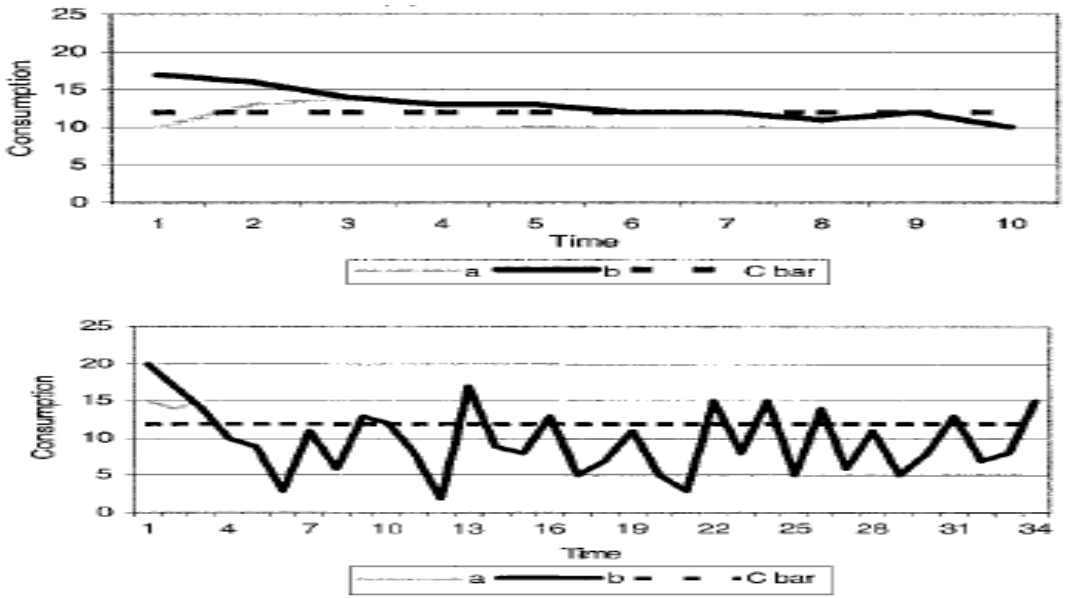
Lei and Noussair (2002)



- In the decentralized market treatment, there was a strong tendency for consumption (as well as capital and the price of output) to converge to the unique steady state values.
- In the social planner (representative agent) treatment, consumption was typically below the steady state level and much more volatile.

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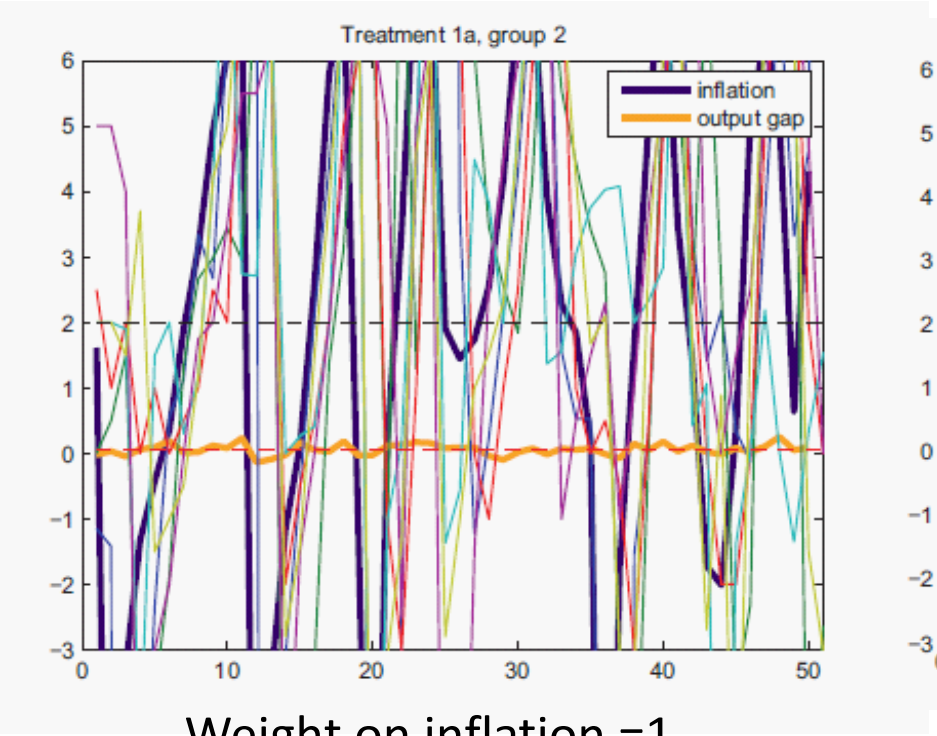
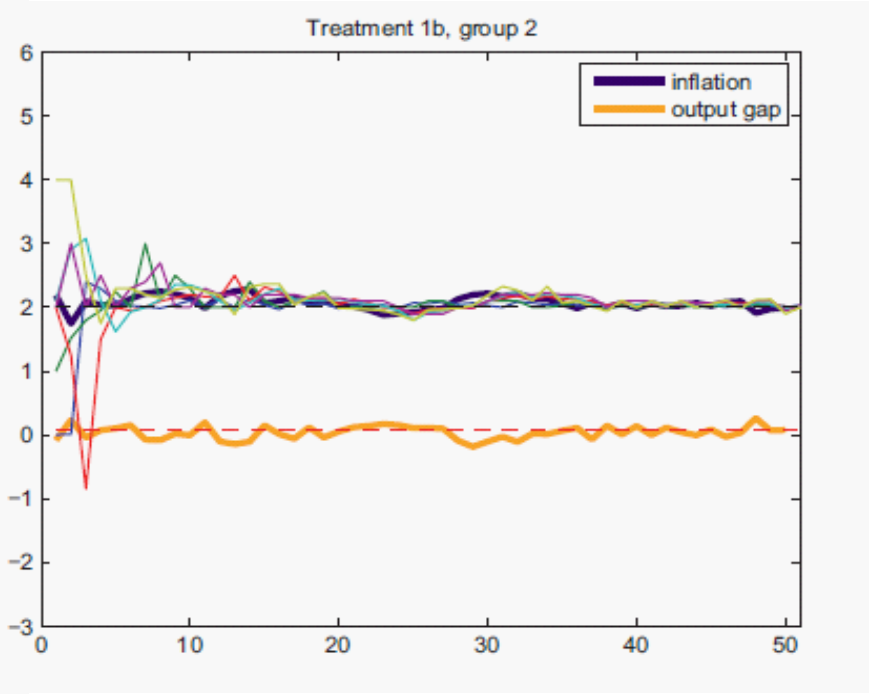
Assenza (2011)



Weight on inflation =1,
Equilibrium is indindeterminate



Weight on inflation =1.5
Equilibrium is determinate

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Nagel (1995)

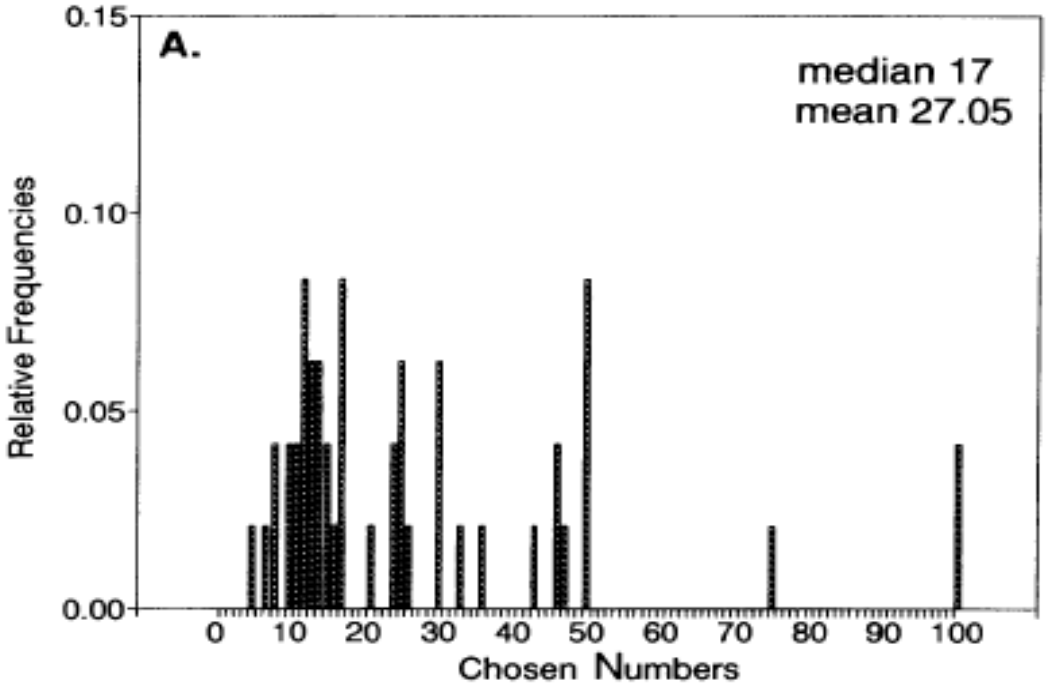

Figure 2 Relative frequencies of numbers in [0,100] chosen in Nagel's (1995) 1/2-mean game (beauty contest). Source: Nagel (1995).

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Hommes et al. (2009)

Strongly Unstable
RE $p^*=5.91$, $\sigma^2=.25$

Unstable
RE $p^*=5.73$, $\sigma^2=.25$

Stable
RE $p^*=5.57$, $\sigma^2=.25$

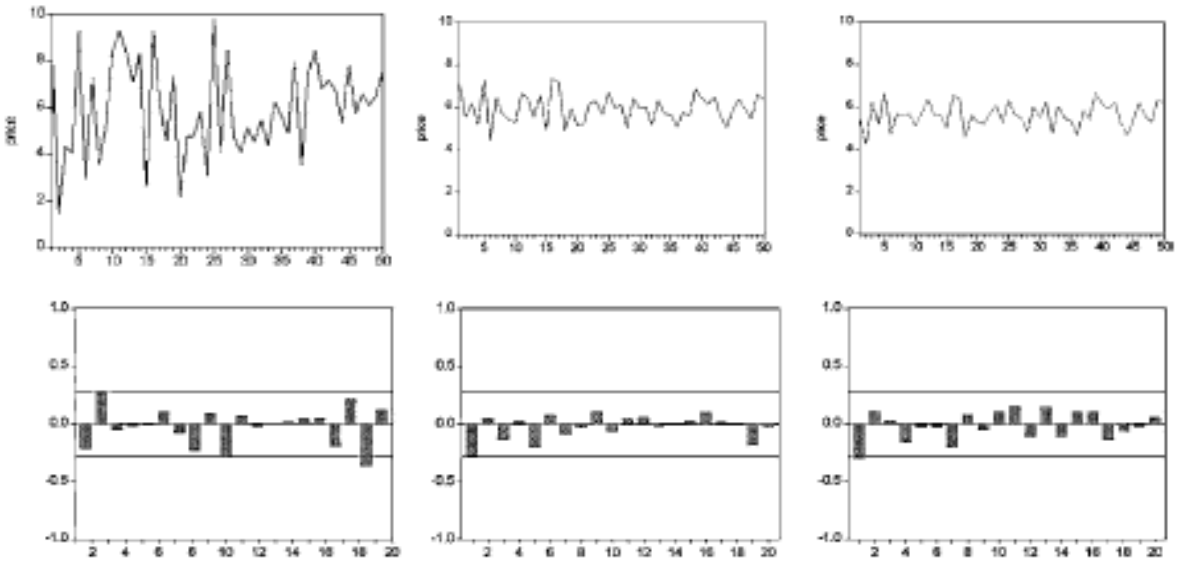

Figure 3 Actual prices (top) and autocorrelations (bottom) from three representative sessions of the three treatments of Hommes et al. (2007): strongly unstable, unstable and stable equilibrium under naïve expectations.

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Capra et al. (2009)

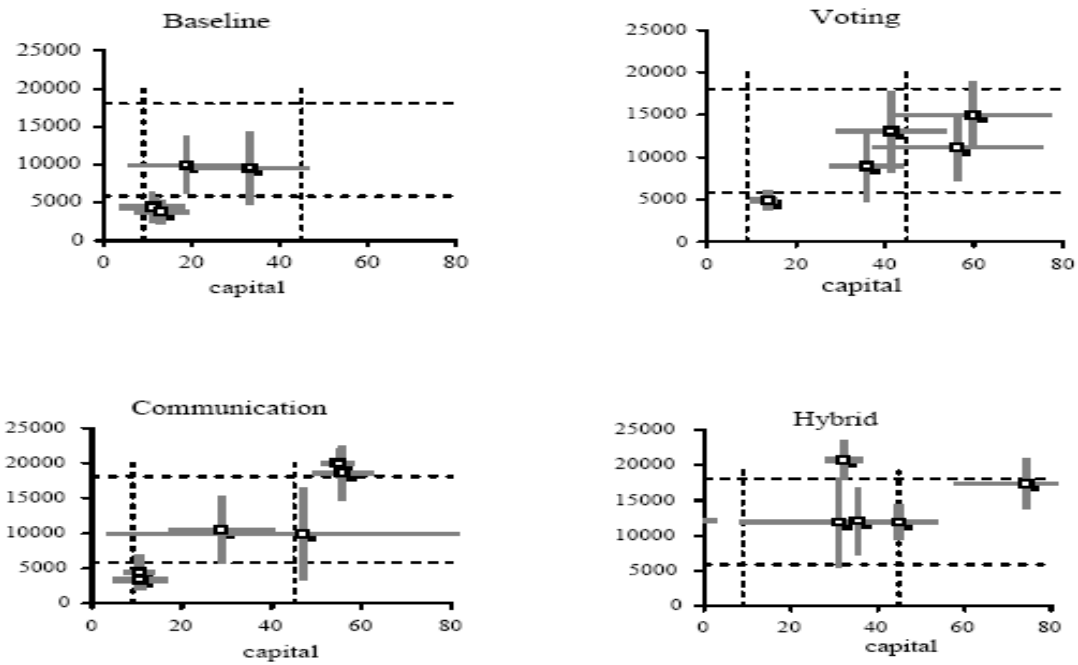

Figure 4 Asymptotic estimates of aggregate welfare (vertical axis) and capital (horizontal axis) for each session (square) of the four treatments of Capra et al. (2009). Line segments give 95% confidence regions. Poverty trap equilibrium is at the lower-left intersection of the two dashed lines, while the efficient equilibrium is at the upper-right intersection of the two dashed lines.

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Duffy and Fisher (2005)

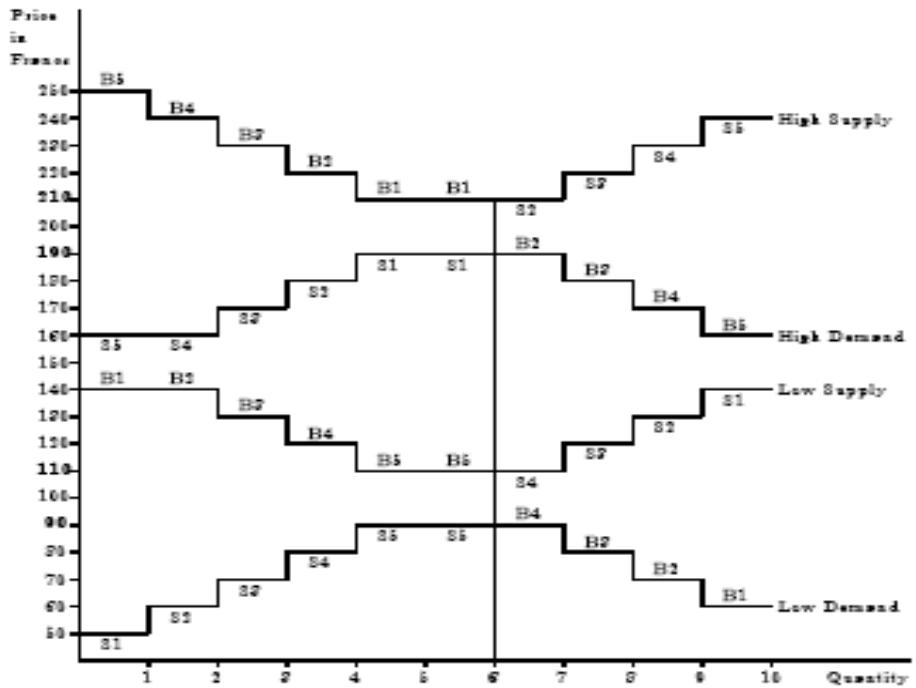

Figure 5: Induced High and Low Demand and Supply in Duffy and Fisher (2005). Buyers: B1--B5, Sellers: S1--S5. Market clearing prices with high demand and supply are [190,210] Market clearing prices with low demand and supply are [90,110]. The equilibrium quantity is always 6 units bought and sold.

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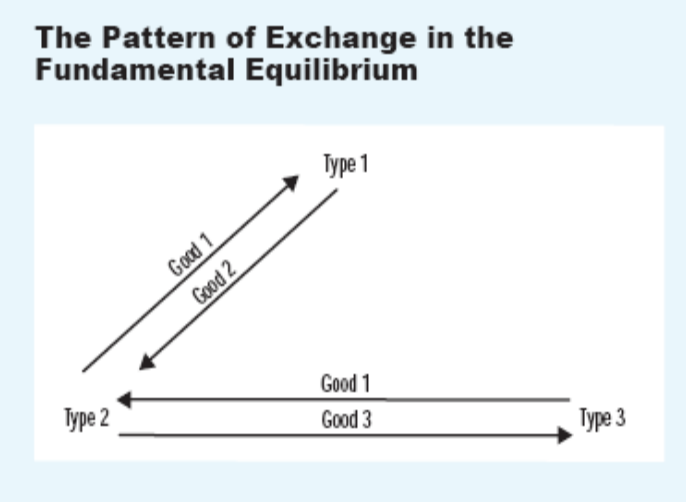
Duffy and Ochs (1999, 2002))



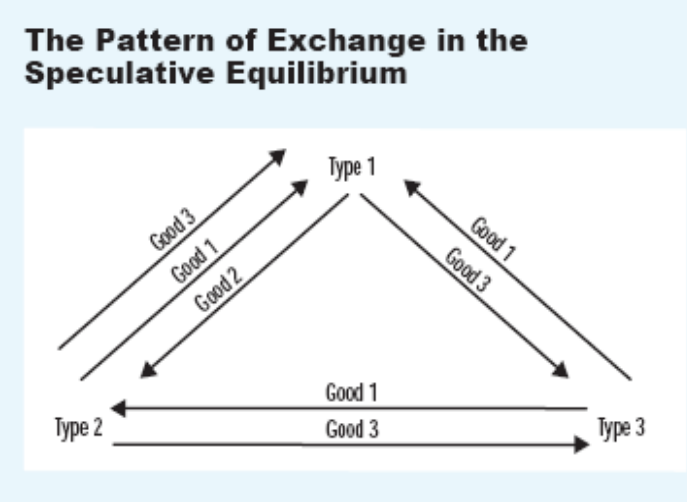


Figure 7: Predicted trading patterns in the fundamental (left) and speculative (right) equilibrium. In the fundamental equilibrium, Type 2 trades good 3 to Type 3 for the lowest storage cost good 1, and then trades good 1 to Type 1 for good 2.
In the speculative equilibrium, an additional trade is predicted: Type 1s agree to trade good 2 to Type 2 for the more costly to store good 3, and then trade good 3 to Type 3 for good 1. Goods 3 and 1 serve as media of exchange, though 3 is more costly.

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Fehr and Tyran

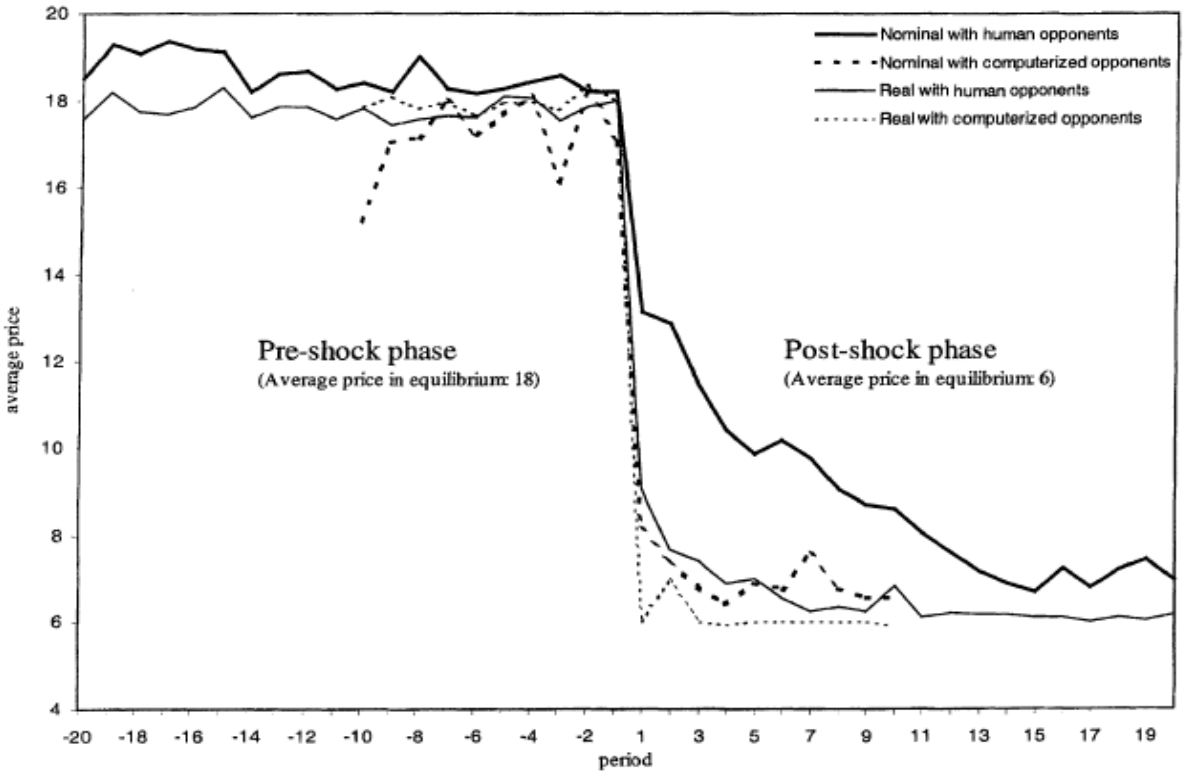

Figure 8: Path of Average Prices in the Four Treatments of Fehr and Tyran (2001). The nominal shock occurs in period 0.

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Fehr et al.

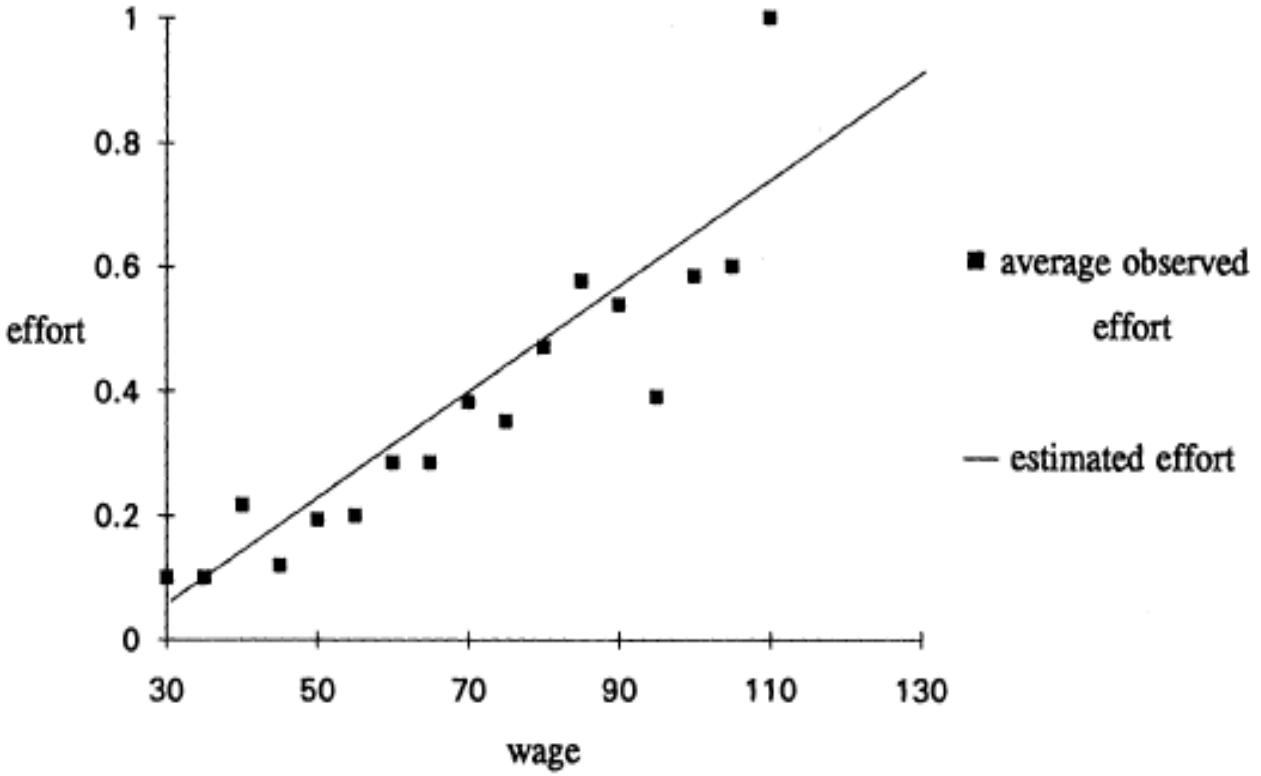

Figure 9: Average Observed Effort as a Function of Wages from Fehr et al. (1993)

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Lian and Plott

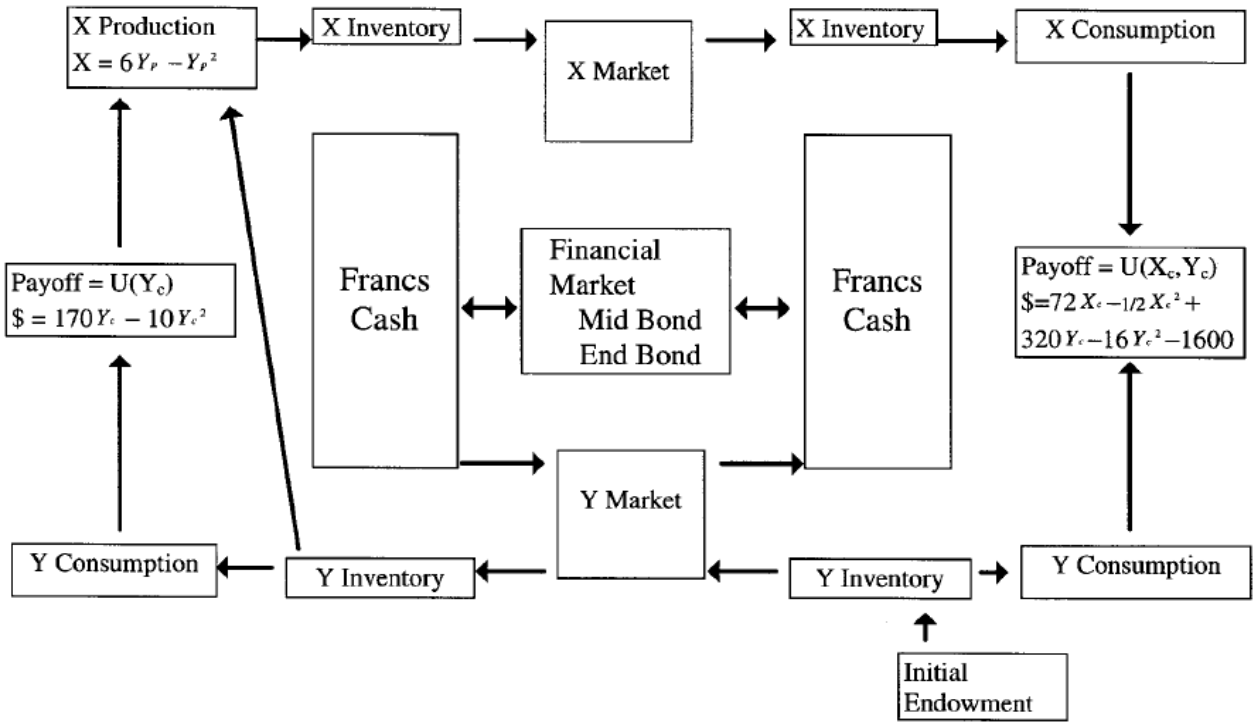

Figure 11: Circular Flow Model Illustrating the Experimental Environment of Lian and Plott (1998). (Source: Lian and Plott 1998-Figure 1)

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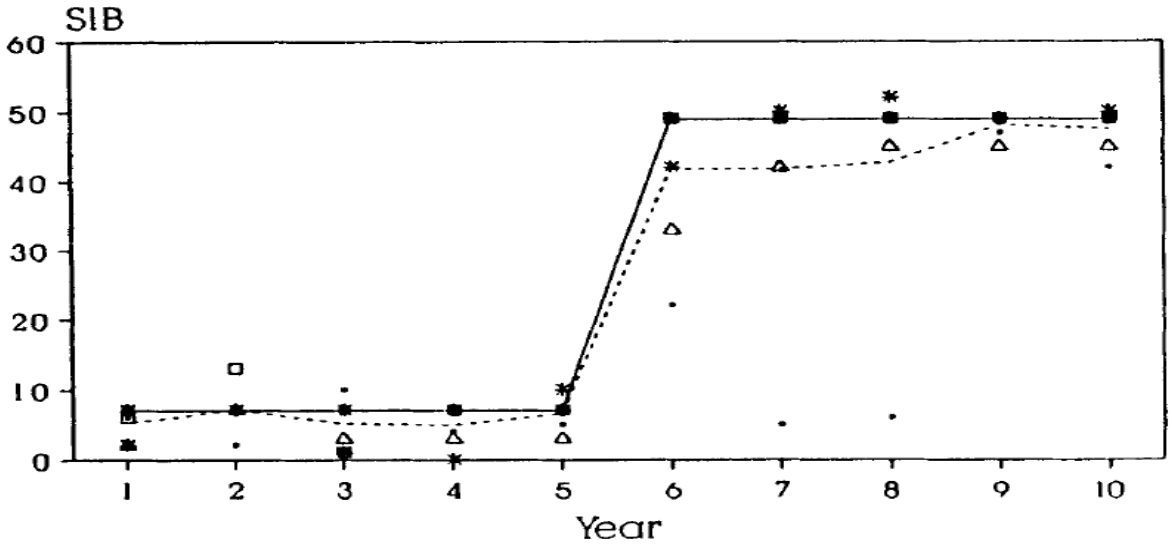
Cadsby and Frank



Symbols represent individual players.
The solid line represents equilibrium.
The broken line shows average bequests.

Figure 12: The temporal path of individual and average bequests s_1^B, in Cadsby and Frank's experiment #3. Source: Cadsby and Frank (1991, Figure 3).

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Van Huyck et al.

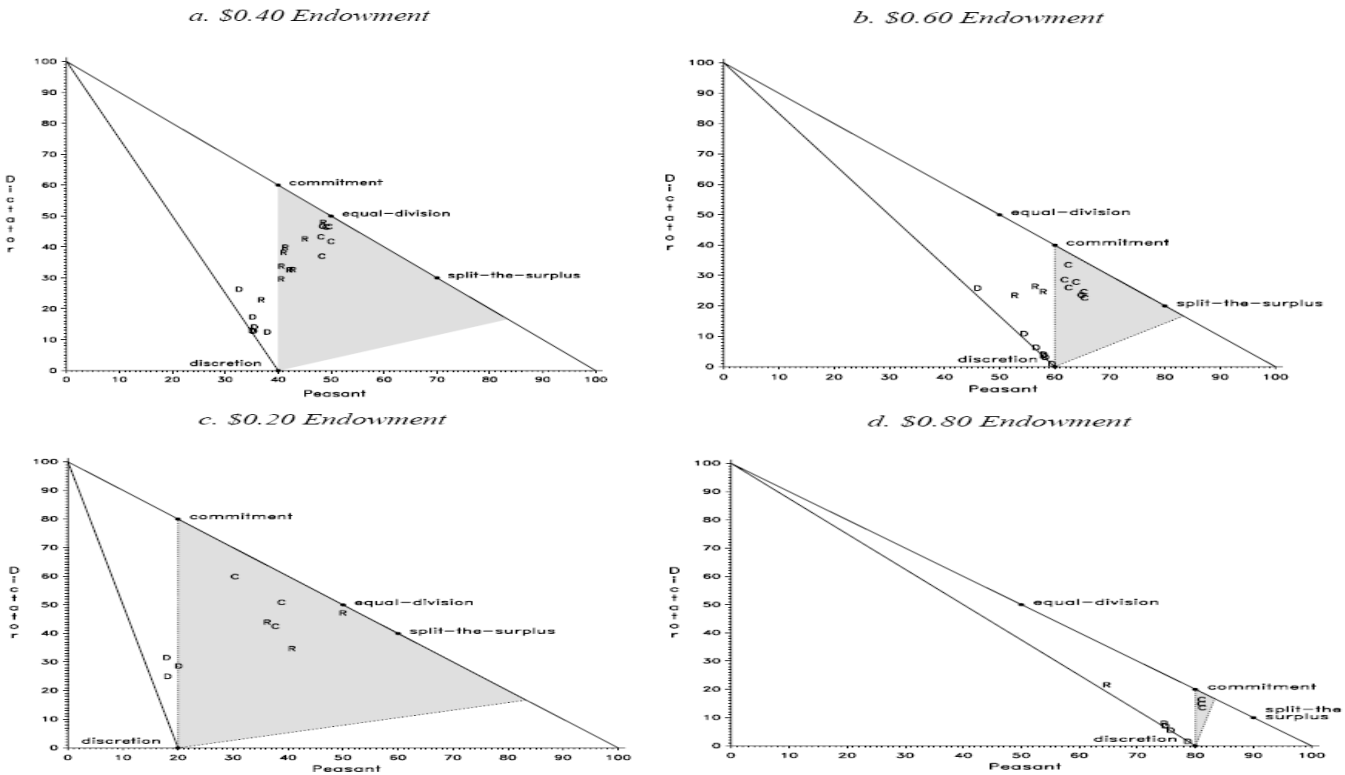

Figure 13: Mean payoffs by cohort: C=commitment, D=discretion, R=reputation in 4 (W,r) treatments of Van Huyck et al.'s (1995, 2001) peasant-dictator game.

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