The Impact of Simple Institutions in Experimental Economies with Poverty Traps

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Abstract

We introduce an experimental approach to study the effect of institutions on economic growth. In our experiment, agents produce output, which they trade in a market and allocate between consumption and investment in each of a sequence of periods. Capital productivity is higher if total capital stock is above a threshold. The threshold externality generates two steady states—a suboptimal "poverty trap" and an optimal "rich country steady state"—which differ by a factor of approximately three in the income they yield. In baseline sessions, in which agents make independent consumption decisions in a decentralized economy, the economies typically converge to the poverty trap and the optimal steady state is never reached. However, the ability to (a) make public announcements, or to (b) vote on competing and binding "industrial policy" proposals, increases output, welfare, and capital stock. Combining both of these simple institutions guarantees that the economies escape the poverty trap.

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1. Introduction

Why are some countries rich while others are poor? While some of the differences in income levels and economic growth can be attributed to differences in resources, geography, and openness to international trade[1], economists recognize that economic and political institutions[2] play an important role. While macro-and development economists have used field data to learn much about the effects of institutions on growth, identifying the precise impact of a particular institution is typically very difficult. Institutions, as observed in the field, arise endogenously rather than randomly, so that there is an endogeneity problem in inferring whether an institutional change influences growth. There are also country-specific cultural and historical factors that are difficult to quantify, which interact with institutions and may affect economic performance[3]. Finally, in naturally occurring economies, different institutions tend to co-occur in clusters (for example, democratic voting and freedom of the press), and the resulting multicollinearity makes it difficult to isolate each institution's individual effect.[4]

In this paper, we illustrate how new data for the study of economic growth can be generated from experimental political economies and how economists can use experimental macroeconomies to study specific institutional questions. We realize that laboratory experiments cannot be used to construct simulations of a national economy and therefore must exclude many important structural and institutional features. Nevertheless, current experimental techniques do allow economists to construct and study specific types of economies of interest. Given that a particular economy is feasible to construct in the laboratory, it can be studied in depth. In the laboratory, experimenters are able to fully observe and control the environment and institutions, which can be changed exogenously so that their effects on an outcome variable (e.g. national income, capital stock, or welfare) can be clearly identified. Institutions can be mixed and matched to create hybrids that may not occur naturally (e.g. dictatorships with a free press), and new institutions can be designed and

[1] E.g., Sachs and Warner (1995, 2001).
[2] E.g., Baumol (1986), Barro and Sala-i-Martin (1995), and Barro (1997).
[3] Acemoglu et al, (2001), Knack and Keefer (1999).
[4] See Temple (1999), Islam (2003) or Durlauf and Quah (1999) for a discussion of empirical methodology and survey of results of empirical research on the determinants of economic growth.

implemented. Results from different institutional configurations can be compared to optima and to equilibria, as well as to each other. Experimental economies can also be replicated. That is, multiple economies can be created under identical conditions. This allows the potential falsification of theoretical propositions at any desired level of significance and the investigation of the variability of possible outcomes under fixed conditions.

In this first experimental study of the effect of institutions on economic growth, we focus on an issue that is particularly conducive to the application of laboratory methodology, that of equilibrium selection.[5] The underlying behavioral questions are whether economies, in which a poverty trap of low output due to an investment coordination failure exists, actually exhibit a tendency to reach that equilibrium, and whether simple institutions enhance the ability of the economy to avoid or exit the poverty trap.

More specifically, the economies we study have two steady states—a poverty trap and an optimal steady state, as in for example Azariadis and Drazen (1990) or Murphy et al. (1989). Since theory gives little guidance about which one of the two steady states ought to emerge, and how institutions might influence convergence to a specific steady state, empirical observations have the potential to be very useful.[6] Our research strategy is in the spirit of Lucas (1986), who suggests that experiments can help us understand what happens when economic theory does not pick one of multiple equilibria.[7] He writes:

> [since] economic theory does not resolve the question….It is hard to see what can advance the discussion short of assembling a collection of people, putting them in the situation of interest, and observing what they do. (p. 421)

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[5] There are previous experimental studies that have been motivated by microeconomic issues in development economics, in contrast to the macroeconomic focus of our research. For example, Cardenas and Carpenter (2004) use field experiments to measure parameters such as social capital and risk preferences in order to study development. See also Angrist et al. (2002) and Ashraf et al. (2004).

[6] The use of experiments to study other economic environments with multiple equilibria has yielded considerable insight about equilibrium selection. These settings include normal form games (see for example Van Huyck et al. (1990) and Cooper et al. (1990)), and extensive form games (see Brandts and Holt, (1993) or Banks et al. (1992) for example). Experiments have also been used to compare the predictive power of adaptive and rational expectations (Marimon and Sunder, 1993; Arifovic, 1997). Plott and George (1992) have conducted experiments with repeated single-period good markets with two competitive equilibria. Duffy and Fisher (2005) have studied a laboratory environment where "sunspots" induce multiplicity of equilibria.

[7] Lucas was referring to environments in which rational and adaptive expectations produce different price trajectories. However, the same argument can be applied to any game or economy with multiple equilibra, for which theory does not provide a clear argument in favor of the emergence of one equilibrium over another.

Following Lucas's suggestion, we construct experimental macroeconomies and observe *what people do* in a highly stylized experimental macroeconomy with multiple steady states. The economy has a structure that is well-known and understood in the community of macro and development economists. Our experimental environment is a straightforward extension of the optimal growth model of Ramsey (1928), Cass (1965), and Koopmans (1965), a classic model that has served as the basis for much of modern growth theory. In our environment, the multiplicity of steady states results from the existence of a threshold externality in capital productivity – there is a level of aggregate capital at which productivity jumps sharply (see Azariadis, 1993). This particular method of generating multiplicity is chosen for methodological reasons: it is easy to implement and simple to explain to subjects.[8] The parametric structure of the economy and the initial endowments are chosen so that the poverty trap is likely to be reached in our "institution-free" baseline treatment. This creates a challenging environment in which it is possible for institutional changes to increase output and welfare.

In contrast to the studies that have focused on coordination (see for instance Van Huyck, et al., 1990,1991, or Cooper et al., 1990) in normal form games, our environment is macroeconomic, in two senses. The first sense is that decisions taken in past periods determine the current sets of available decisions and feasible outcomes. Such dynamic linkages are the core characteristics distinguishing macro models from many other economic models (such as repeated stage games, where the only linkage is through the history of decisions). Thus, biases in dynamic decision making, strategic uncertainties about future decisions of others, and persistence of the effects of suboptimal decisions, which affect the values of parameters in the future, potentially influence outcomes in our model, as they do in real macroeconomies. Secondly, the environment has the explicit structure of a macroeconomy, with individuals making consumption, investment, purchase and sale

[8] The idea that multiple equilibria exist in macroeconomies, originally attributable to Rosenstein-Rodan (1943), has led to a variety of growth models with multiple equilibria. For instance, Azariadis and Drazen (1990) construct an overlapping generations model with two stable Pareto-ranked equilibria. In the inferior equilibrium, no agent trades with members of other generations. Murphy et al. (1989) build a model with synergies among industries, where each industry is profitable if and only if other industries operate. There are Pareto-dominant equilibria where all of the industries operate and dominated equilibria where none operate. Galor and Zeira (1993) and Banerjee et al. (2001) show that inequality and the resulting differential access to credit can keep an economy in a Pareto-dominated equilibrium. See Azariadis (1993) and Cooper (2002) for a detailed treatment of the principal analytical issues in growth models with multiple equilibria.

decisions, and includes markets and a transferable numeraire good, money. These are all features of all real macroeconomies, but are absent in the reduced-form coordination games that have been previously investigated with experiments.

Adding complexity is important because coordination on the high-payoff equilibrium may be more difficult when the economic activities are complex (as seen in Ho and Weigelt (1996)). Because the experiments are small in scale, however, they could equally well be interpreted as relevant to organizational processes such as R&D budgeting within firms. In these settings, a small set of people invest organizational resources, there is a threshold externality if enough resources are committed, and various mixtures of open debate and formal voting over proposals may enhance coordination on a high-productivity firm-wide investment plan, much as in our experiments.

The first institution we consider in this dynamic multiple steady-state environment is open communication. The ability to send messages to all other members of society, and to coordinate those messages in opinion polls and news media, is the natural analogue of communication to macroeconomic environments (such as freedoms of press, assembly, and speech). In our experiments, all agents are allowed to make public announcements, unrestricted in content, in a "chat room" before investment decisions are made in each period.[9] The reason we choose to investigate the role of communication is because previous experiments on games with multiple equilibria suggest that allowing communication can sometimes improve coordination on a Pareto-superior equilibrium (see Camerer, 2003, chapter 7; Devetag and Ortmann, 2007). However, communication does not always improve coordination in simple games, so it is an open question whether it will work in more complex environments. Recording the messages also allows us to eavesdrop on what agents are thinking, which is often insightful, and to explore which *types* of messages are most likely to improve investment and welfare (Brandts and Cooper, 2005, offer an excellent example).[10]

[9] While experimental economists and game theorists would define any types of rules of interaction that govern what agents do and say (e.g., communication) as institutions, this term may have a different interpretation in political economy. In spite of this, it is worth noting that in some developing countries (e.g. Bolivia and Nigeria) a specific form of communication, dialogue (a process of consultation at local and state levels and in sectorial workshops) is taken very seriously as part of the policy making process.

[10] Brandts and Cooper (2007) study the effect of communication by 'managers' on coordination in a weak-link game in a manner much like we do. They conclude that "communication is a more effective tool than incentive changes for leading organizations out of performance traps" (cf. Brandts and Cooper, 2006).

The second institution is a competitive direct democratic process, in which an "industrial policy" is determined. Two agents in the economy each submit a proposal specifying the quantity that each agent will consume and invest. Citizens vote for proposals and the one chosen by the majority is implemented. The rationale for investigating this institution is that there is reason to believe that it may perform well. The fact that the winning proposal is binding on all agents may serve to eliminate the strategic uncertainty that accompanies the coordination problem, and this might improve outcomes. Our third institutional structure combines communication and voting to consider whether they interact. A synergy may occur, for example if agents debate the merit of different policies before voting or submitting proposals. Alternatively, the two institutions may crowd each other out if either one, separately, succeeds in increasing output and welfare as well as both of them together.

Implementing the two institutions together resembles the direct democracy system developed in ancient Athens. All adult male citizens could speak and vote in the meetings of the assembly. Members of the council (called the boule) were selected by lottery prior to meetings to prepare the agenda. Our communication and voting experimental treatments closely parallel the Athenian ones: All agents in our experiments can speak openly to others, and in the voting treatment, two agents are chosen at random to generate proposals that are then voted upon. (Interesting extensions, like endogenous selection of candidates to create proposals based on campaigns, could be included in future experiments).

Athenian democracy is interesting for at least two reasons. First, throughout history, political institutions similar to Athenian democracy have independently emerged (see Hansen, 1992). According to Matsusaka (2005), over 70 percent of the American population now live in either a state or a city where direct democracy is exercised. Second, while Athens is considered to have been the most stable and successful democracy among the ancient Greek states, little is known about why its democratic system was more successful than others' (e.g., oligarchy). Understanding why Athenian democracy worked so well in part requires the counterfactual condition of comparing those institutions to a baseline condition without such institutions, which we can do in a modern experiment (a kind of experimental approach to economic history).[11]

Of course, experiments like these are much simpler than the naturally occurring economies we hope to eventually understand. For now, the primary guides for experimental design are the existing theoretical models and simple institutions which previous research suggests have the potential to resolve strategic uncertainty. We deliberately begin with a simple setup, described in section two, that can be complicated in future experiments (a method used in all successful laboratory sciences). Starting with a more complicated design would be less likely to produce reliable results, and would make it more difficult to know which factors caused particular outcomes. Because the design is simple, the manner in which we create "free expression" and "democratic voting" captures only the most basic features of similar institutions when they occur naturally. Readers of this article can probably imagine many different versions of these institutions and other interesting designs. However, since the idea is to begin a research program, we believe that it is most constructive to first focus attention on what has been learned from initial design choices, and to later consider what might happen in other experimental designs. This research could also stimulate a dialogue between the development and experimental economic research communities on the best avenues to pursue in conducting a systematic experimental investigation of the effects of institutions on economic growth.

The next section describes the experimental economy, the theoretical predictions, and the procedures of the experiment. In section three the results are reported. Section four is a summary and lists ideas for future research.

2. The experimental environment, competitive equilibria, and procedures

2.1. The environment

We used the environment first studied by Lei and Noussair (2007), hereafter LN, and employed the same parameters as in their Low Endowment treatment (except for the use of a different capital-trading institution which required entirely new software development). LN

[11] Olken (2007) reports a remarkable experiment comparing a form of direct democracy at the village level (direct voting for a public good program) with a system based on meetings of representatives. The direct system produces higher satisfaction although it does not lead to fundamentally different decisions.

studied an economy in which resource allocation was conducted through decentralized markets and independent individual consumption/investment decisions, as in the Baseline treatment of our design. No communication or voting was possible in their design. They found that the economies in their Low Endowment treatment exhibited a strong tendency to converge to the poverty trap. Thus, this particular parametric structure provides an arena in which there is scope for additional institutional structures to improve outcomes[12].

The economy may be thought of as populated by an infinitely-lived representative consumer with a lifetime utility given by:

$$\sum_{t=0}^{\infty}(1+\rho)^{-t}U(C_t) \ , \qquad (1)$$

ρ is the discount rate, C_t is the quantity of consumption at time t, and $U(C_t)$ is the representative consumer's utility of consumption. Alternatively, the expression in equation (1) may be thought of as the total value that an infinitely-lived group of agents receives from consumption. The economy faces a resource constraint:

$$C_t + K_{t+1} \le A * F(K_t) + (1-\delta)K_t, \qquad (2)$$

with

$$A = \begin{cases} \underline{A}, & \text{if } K < \hat{K} \\ \overline{A}, & \text{if } K \ge \hat{K} \end{cases}. \qquad (3)$$

δ is the depreciation rate, K_t is the economy's aggregate capital stock at the beginning of period t, and A is an efficiency parameter on the production technology. The value of A depends on the current level of capital stock in the economy. A has the value $\overline{A}$ above a threshold level of capital stock, $\hat{K}$, and has the value $\underline{A}$ below $\hat{K}$, with $\underline{A} < \overline{A}$. The threshold can be interpreted as a positive externality in production, generated by a sufficiently large aggregate quantity of capital stock in the economy.[13] [14] Table 1 lists the numerical parameters of the experimental economy.

[12] The only difference between the Low Endowment treatment of LN and the Baseline treatment of our study is that LN used continuous double auction market trading rules to conduct trade, while we employ call market trading rules. Since the results are very similar between the two data sets, the choice of trading rules did not appear to have an effect.

[13] See Azariadis (1993) and Azariadis and Drazen (1990) for discussion of growth models with a threshold externality in production.

[Table 1: About here]

In the experiment, the aggregate production capability and the value of consumption of units of output are divided among five heterogeneous agents populating the economy. Each subject *i* is given two individual production schedules that show how his current capital k_t^i is transformed into output $A * f^i(k_t^i)$, depending on whether total capital $K_t = \sum_i k_t^i$ is above or below the threshold of 31 (see Figure 1). The marginal utility of consumption of agent *i* is a discrete approximation of $v^{i}{}'(c_t^i) = 396 + 4i - 20c_t^i$. The utility function for consumption is expressed in terms of an experimental currency called "Yen," which is converted into US dollars at the end of the experiment at a predetermined, privately-known exchange rate. As in most market experiments, agents' utility and production functions were private information. The economy's *aggregate* production and demand curves are shown in Figure 2. In the experiment, each subject had different privately-known curves,[15] and no subject directly saw the aggregate curves shown in Figure 2.

[Figure 1: About Here]
[Figure 2: About Here]

2.2. Competitive equilibrium

In this economy, the equilibrium has two stable steady states. One of these is an optimal steady state. The optimal steady state is the outcome the economy would asymptotically converge to if it were under the direction of a benevolent social planner. Such a planner would choose $C_1 \ldots, C_\infty$ to maximize (1), subject to (2), (3), and the constraints that

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[14] Benhabib and Rustichini (1996) introduce a growth model where the allocation of aggregate output is the outcome of strategic choices made by different social groups. In their model, two players, representing large social groups in the economy, make consumption choices over an infinite horizon. They show that, under particular parameter values, growth can be more rapid when capital stock is high than when it is low, a phenomenon consistent with the existence of a poverty trap. With their model, they provide an intuition about the mechanism whereby strategic interaction between conflicting sectors of society can explain why rich countries have grown faster than poor countries.

[15] Making individuals' demand, endowment and cost information private is the typical practice in experimental markets and has the effect of enhancing convergence to competitive equilibria (Smith, 1994).

$C_t \geq 0$, $K_t \geq 0$ and $K_{t+1} \geq (1-\delta)K_t$ (gross investment in every period must be non-negative). Table 2 shows the values of the key variables in the optimal[16] and sub optimal (poverty trap) steady states.

[Table 2: About here]

2.3. Procedures

2.3.1. General procedures

The experiment consisted of a total of 21 sessions. There were four treatments in the experiment, which differed only by the institutional structure of the experimental economy. The four treatments are called *baseline*, *communication*, *voting*, and *hybrid* (each is described in more detail later). Subjects were undergraduates at Emory University and the California Institute of Technology. Table 3 details when and where sessions were conducted, and the average earnings.[17] Subjects participated in this experiment only once (though many had been in other, unrelated experiments). The next three subsections briefly describe the experiment.

[Table 3: About here]

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[16] In equilibrium, the optimal steady state capital/consumption combination, $(K_t, C_t) = (45, 70)$, has the property that from any initial level of capital stock $K_0 > 0$, including $K_0 = 9$, the optimal sequence of consumption and investment decisions of a hypothetical benevolent social planner converges to (45, 70). At this optimal steady state, each agent consumes 14 units per period for an economy-wide total of 70 units of consumption, and the capital stock is distributed among the agents in the following manner: $\bar{k}^1 = 12$, $\bar{k}^2 = 9$, $\bar{k}^3 = 6$, $\bar{k}^4 = 8$, and $\bar{k}^5 = 10$, where $\bar{k}^i$ is the equilibrium capital holding of agent *i*, yielding a total of 45 units. In the poverty trap, agents 1, 2, 3, and 4 each consume 3 units and agent 5 consumes 4 units per period for a total consumption of 16. The allocation of capital stock in this equilibrium is $\bar{k}^1 = 1$, $\bar{k}^2 = 2$, $\bar{k}^3 = 1$, $\bar{k}^4 = 2$, and $\bar{k}^5 = 3$, yielding a total equilibrium capital stock of 9 units.

[17] All sessions were conducted in dedicated experimental laboratories at the two universities. Subjects were paid an initial fee of either $5 or $10 for their participation, depending on the session and their role in the experimental economy. Additional earnings from their activity in the economies described below ranged from $11.56 to $47.26.

2.3.2. Timing within a session

Five agents participated in each session and were grouped together in the same economy. In each session, the experimenter distributed instructions, read them aloud, and conducted a three-period practice horizon (which did not count toward subjects' earnings).

Each session had several horizons, each with a variable number of periods. The number of periods in each horizon was determined by rolling a ten-sided die, after each period. If the die came up 1 or 2, the horizon ended and all capital disappeared. If the die came up 3-10, the horizon continued. The number of horizons in different sessions ranged from 2 to 8 (see Table 3). In theory, if agents are risk-neutral, then a random ending should induce behavior which is theoretically equivalent to an infinite time horizon with discounting (as in section 2.1). The random ending appears to work adequately in other experimental domains.[18]

Each session was scheduled for a three-hour time interval. The instructions indicated that if the current horizon ended with more than 30 minutes remaining in the three-hour interval, a new horizon would be started with the same initial endowments of 5 units of capital and 10,000 Yen per person. Since initial endowments for each new horizon were independent of any activity in prior horizons, restarting after an exogenous random ending does not distort optimal decisions.[19]

2.3.3. Timing within a period

The sequences of activities within each period, in each of the four treatments, is shown in Figures 3a – 3d. In all treatments, each period consisted of two decision stages: trading in a market for output (stage 1), and either a private or a voting procedure to determine consumption (stage 2).

[18] Under the assumption that agents in the experiment are risk neutral in their final monetary payment, a constant probability of 20% of the horizon ending in each period is equivalent to an infinite horizon in which ρ=0.25. Other authors have used a similar rule to create the incentives of infinite horizon models in the laboratory. See for example Camerer and Weigelt (1993), Noussair and Matheny (2000), and Lei and Noussair (2002, 2007).

[19] Behavior in subsequent horizons could depend on previous horizons if strategies are conditioned on commonly observed history, of course. (For example, after a horizon ended with inefficient output, future horizons could also be inefficient due to pessimistic expectations.) Our point is simply that capital holdings do not carry over and so, in principle, players could "restart" after a bad horizon with fresh endowments and ignore previous capital holdings. Whether they do so is an empirical question.

The timing within a period of the baseline treatment is depicted in Figure 3a. In the baseline treatment, the timing of events within a period were as follows: At the beginning of period t, production occurred automatically as the computer program mapped k_t^i, the capital stock that each individual held, into output ($c_t^i + k_{t+1}^i$), according to the individual's production function f^i (k_t^i). Subjects then participated in a market for output (stage 1). Each agent received an endowment of cash (10,000 currency units) to buy and sell output. The cash was convertible to dollar earnings at a conversion rate that was privately known to each subject in advance, so the cash had intrinsic value. Since the agents' utility and production functions were different, there were potential gains from trade from the exchange of output.

Output was traded in a "call market".[20] Agents submitted demand curves specifying a sequence of (weakly) declining integer limit prices for each unit of capital that they wished to buy.[21] An aggregate demand curve was then constructed from the individual demand curves. The aggregate supply curve was vertical and equal to the total amount of output available in the economy for the current period, K_t. The market-clearing price, P_t, was the lowest accepted bid—the K_t-th highest bid among all players, which is also the intersection of aggregate demand and supply. A player's gross purchase of capital was the number of units he or she demanded at price P_t or higher (with ties at the price P_t broken randomly). The net purchase of capital was the gross purchase minus the pre-trade holding. After the market was called, each agent either (a) paid P_t for each net unit he purchased, or (b) received P_t for each net unit he sold.[22]

In stage 2, agents chose how much of the output to consume. In the baseline treatment, after market transactions were made, agents chose how much of their new post-trade output

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[20] Call markets do not converge as rapidly as double auctions, but they are fast to execute and enable many units to trade rapidly, which is an important property in an environment where there can be a large number of units of output, and which allow us to have many periods and multiple horizons. However, our baseline results replicate Lei and Noussair's (2007) identical economy which used double auctions, suggesting a robustness of basic findings across output-trading institutions.

[21] Agents submitted at least one positive price for each unit they held. For example, an agent with 14 units had to submit at least 14 positive prices. This guaranteed that the aggregate demand curve did not result in a zero price.

[22] In formal notation, the market reallocated output in the following manner. In period t each agent i submitted a demand curve $d_i^t(p)$, where p was the price of output. An algorithm then calculated $\_{i}d_i^t(p)$, and solved for the price p^* at which $\_{i}d_i^t(p^*) = \_{i}f_i(k_i^t)$. Agent i's final allocation of output was equal to $d_i^t(p^*)$. The net change in his holding of output was equal to $d_i^t(p^*) - f_i(k_i^t)$. Each agent i received a cash transfer of $p^*[f_i(k_i^t) - d_i^t(p^*)]$.

to allocate to consumption c_t^i. Before making their decisions, agents could use a simulator which allowed them to study, by submitting hypothetical consumption and investment scenarios, how their choice of c_t^i affected their utility of consumption $u_i(c_t^i)$, their remaining capital stock k_{t+1}^i, and the quantity of output they would have at the beginning of the next period $f^i(k_{t+1}^i)$. If the horizon continued (with probability 0.8), the unconsumed output of each individual automatically became k_{t+1}^i. At the beginning of period $t+1$, production occurred as k_{t+1}^i was mapped into output $(c_{t+1}^i + k_{t+2}^i)$, according to the function $f^i(k_{t+1}^i)$, for all i, and the sequence repeated itself.

The sequence of events in the communication treatment (Figure 3b) was identical to the baseline treatment, except that agents were allowed to communicate with each other *before* the call market opened. Each agent's screen displayed a chat-room, which could be used to send and receive messages in real time for up to three minutes. Communication was unrestricted and all agents could read all messages.

The sequence of events in the voting treatment (Figure 3c) was identical to the baseline treatment until stage 2. In stage 2, consumption was not determined privately by individual agents as in the baseline treatment. Instead, two agents were randomly chosen[23] in each period and told the amount of output currently held by each agent after the output market had closed (note that the proposers did not know other agents' utility or production functions, which remained private at all times). Proposers then submitted proposals specifying how many units each agent in the economy would consume in that period. A proposal was a five-element vector of consumption levels, one element corresponding to each agent. The two proposals appeared simultaneously on all agents' computer screens. All agents were then required to vote for exactly one of the two proposals. The proposal that got the majority of the five total votes was enacted, and each agent consumed the amount specified in the winning proposal.

[23] Endogenizing which agents make proposals, and "campaigning," are obvious next steps. Because the experiments are already rather complex, we elected to begin with the simplest "anybody can grow up to be President" design. It also provides a benchmark sample of random-proposer sessions against which endogeneous-proposer designs can later be compared.

The first stage of the hybrid treatment (Figure 3d) was identical to stage 1 of the communication treatment. Stage 2 was identical to that of the voting treatment. Note that in the hybrid treatment, communication takes place *before* proposals are made and voted upon.

[Figures 3a-3d: About here]

2.3.4. Initial Endowments and Agent Incentives

Each of the five agents received an initial endowment of five units of capital, so the aggregate initial capital stock was $K_0 = 25$. The initial endowments were chosen so that the poverty trap outcome was likely to occur (based on earlier results of Lei and Noussair, 2007) in the baseline condition. This design choice permits us to see whether institutions can get economies out of the poverty trap.

Player *i*'s period t earnings, in terms of experimental currency, were given by $u_i(c_i^t) + m_{i1}^t - m_{i0}^t$, where $u_i(c_i^t)$ denotes *i*'s earnings from consumption, and m_{i0}^t and m_{i1}^t denote *i*'s cash holdings at the beginning and the end of period *t*, respectively. Over an entire experimental session, participant *i*'s dollar earnings were equal to _*i*+ _i(_*j*_*t*[$u_i(c_i^t) + m_{i1}^t - m_{i0}^t$]). Subscript *j* indexes the horizon within an experimental session, *t* is the period within a horizon, _i is agent *i*'s conversion rate from experimental currency to US dollars, and _*i* is agent *i*'s fixed participation fee.[24] Because there was always an 80% chance that the current horizon would continue, each individual had an incentive to hold some output in the form of investment to allow consumption or sales in future periods in the horizon. An agent also had an incentive to sell output if the price was high, in order to increase his end of period cash holdings, as well as an incentive to purchase output at low prices in order to consume, produce more output in future periods, or resell in future periods at a higher price.

2.4. Anticipated Treatment Effects

[24] The values of the fixed payments were $5 for players 1 and 2, and $10 for players 3, 4, and 5. The difference was to compensate players 3-5 for earnings in the experiment which were expected to be lower than for players 1 and 2. In the baseline treatment, _i was 0.001 (1 Yen = _i US dollars for player *i*) for player 1 and 0.002 for players 2-5. In the other three treatments earnings were expected to be higher (and usually were), so the conversion rates were cut in half (_i was 0.0005 for player 1 and 0.001 for players 2,…, 5).

The four treatments in our experiment allow us to consider whether communication and voting separately, as well as in combination, increase the likelihood that the economy avoids or escapes the poverty trap and reaches higher levels of output and welfare. In our economies there is a coordination problem that requires agents to conserve enough output, together, to push aggregate capital above the threshold level. The challenge for the institution is twofold. Firstly, it must to make individuals aware of the possibility of increasing welfare by surpassing the threshold, and this may require a means of transmission of information from some individuals to the others. Secondly, the institution must mitigate the strategic uncertainty that may prevent individuals from reducing their short-term consumption to achieve the greater long-term welfare gains when the threshold is exceeded. Communication may facilitate making the possibility of coordination common knowledge, because it allows one person who is aware of the possibility to inform the others, and all players to presume that other individuals have observed the message. The reduction in strategic uncertainty, when individuals indicate an intention to invest, may induce a sufficient number of individuals to take a short-run risk for the potential future benefit. If the threshold is surpassed subsequent communication can reinforce this behavior.

The voting process allows one person who becomes aware of the group incentive to surpass the threshold to communicate the possibility, once he has an opportunity to make a proposal. While this process may operate more slowly in making the possibility of coordination common knowledge than explicit communication, the voting process effectively eliminates strategic uncertainty in the investment decision. When presented with proposals that allow the economy to exceed the threshold, individuals may eventually realize that it is in their own interest to vote for one, especially after they understand that the binding nature of the proposals eliminates strategic uncertainty. The high payoffs achieved after the threshold is exceeded may provide sufficient inducement to continue to vote for similar proposals in the future.

Communication, in conjunction with voting, may accelerate the process of capital accumulation toward optimal levels. The communication enables agents to talk about what kinds of consumption plans are best, and may quickly make the possibility of successful coordination common knowledge. This can be immediately reflected in the proposals that are submitted. The voting process removes the strategic uncertainty that exists from the incentive individuals have not to carry out their stated intentions to reduce consumption. The potential for synergy is also suggested from the fact that most modern democracies also have considerable freedom of speech.

The field evidence is consistent with the notion that the instruments we study improve output. The presence of institutions promoting communication between economic agents, such as free speech or a free press, has been statistically associated with higher rates of economic growth (Barro and Sala-i-Martin, 1995; Barro, 1997), as have democratic institutions (Barro and Sala-i-Martin, 1995), although it is unknown, because the underlying structure of non-laboratory economies is unobservable, whether they enhance growth by facilitating coordination or through another mechanism.We thus hypothesize, ex-ante, that the communication and voting treatments improve output and welfare over the baseline treatment, and that the hybrid treatment achieves higher output and welfare than the other three treatments.

3. Results

The results section proceeds in four parts. In the first two subsections, we present comparisons across sessions and treatments. In subsection 3.3, we analyze the different sources of inefficiencies in the economy. In subsection 3.4 we look at how economies manage to avoid the poverty trap, and how communication and voting work and interact.

3.1 Basic Empirical Patterns

Figures 4 – 7 show aggregate consumption behavior, C_t, in each session of the four treatments. Consumption is highly correlated with welfare and therefore the time series for welfare show very similar patterns. Each chart illustrates the time series of C_t for one session. Each figure shows all the sessions from each treatment. The horizontal axes show the periods in a session. The dashed horizontal lines are the optimal steady state and poverty trap levels of consumption, which are C^*_H=70 and C^*_L=16, respectively. The discontinuities in the time series represent the starts of new horizons. Analogous data for aggregate capital stock K_t across the four treatments are depicted in Figures 8 - 11.

[Figures 4 – 11: About Here]

Figure 4 shows that for the baseline treatment, the poverty trap is a powerful attractor. In four of five sessions, consumption (Figure 4) and total capital (Figure 8) remain close to the poverty trap level. Figure 8 shows that in one of these five sessions (Emory B3), the economy invests sufficiently in capital to surpass the threshold of 31 units in the first horizon, but it is unable to attain the threshold level of capital after that horizon ends, in the remainder of the session. In another session, Caltech B2, the capital stock surpasses the threshold in two different horizons, but in three horizons between these two, the economy is in the poverty trap. These sessions show that avoiding the poverty trap in early periods or early horizons does not guarantee successful avoidance of poverty traps later. The fact that these baseline economies do not persistently exit the poverty trap replicates the results of Lei and Noussair (2007).

In the communication treatment, outcomes are more variable among sessions. Although all economies have an identical parametric structure, and the members of the different economies are drawn from the same population, they follow very different trajectories from each other for reasons that are completely endogenous. The behavioral differences between this treatment and the baseline treatment illustrate that institutions can alter both the expected income of an economy and its variance. Two of the sessions, Caltech C2 and Caltech C3, surpass the threshold level and consistently move towards a consumption level close to the optimum. Two other sessions, Emory C3 and Caltech C1, remain near the poverty trap level of consumption. In one of the remaining two sessions, Emory C1, the economy is moving close to the optimal steady state in the last of the two horizons of the session. Finally, one session, Emory C2, exhibits behavior that is difficult to categorize, but is highly variable from one period to the next (see Figure 5).

As shown in the charts of Figure 6, the voting treatment exhibits more variability within sessions than either the baseline or the communication treatments. The reason lies in the centralized nature of decision making. In contrast to the baseline and communication treatments where decentralized decision-making on the part of individuals determines consumption and investment choices in each period, in the voting treatment investment and consumption decisions are made by majority choice from a small and changing set of alternatives. This results in rapid swings in economic outcomes from period to period. Indeed, in only one of the sessions, Emory V2, consumption remains consistently close to the poverty trap level. A closer look at the individual data shows that some proposals reflect a preference for a high level of current consumption rather than for building up sufficient capital to surpass the threshold and the majority of the subjects will, at times, vote in favor of such proposals. Individual behavior in the voting treatment is considered in more detail in subsections 3.4.1 and 3.4.2.

A similar pattern of highly variable activity exists in the hybrid treatment. As in the voting treatment, it appears that the voting process impedes a smooth convergence to the optimal equilibrium, because it causes shocks to the economies' level of capital. However, in contrast to the previous treatment, in the hybrid treatment, the economy reliably escapes the poverty trap. As shown in the session charts of Figure 7, every session shows late horizons that are characterized by consumption levels closer to the optimal equilibrium than to the poverty trap. In addition, the levels of capital are consistently in excess of the threshold of 31 from period four onward in all the sessions.[25]

Since the experimental sessions are constrained by the time in which agents can continuously participate, it is useful to have a rough extrapolation of what might happen if the sessions continued longer. The best available econometric tool is a statistical model that uses all the data from one session to forecast what would be likely to happen if that session continued indefinitely. Equation (4) is a specification, used previously[26], which uses data from one session to forecast long-run behavior:

$$Y_{jt} = B_1 \frac{1}{t} + B_2 \frac{t-1}{t} + \varepsilon_j + \nu_{jt} \qquad (4)$$

In this regression, Y_{jt} is a dependent variable of interest, either the total utility $U(C_t) = \sum_i u_i(c_i^t)$ actually realized in the economy, or the economy-wide capital stock $K_t = \sum_i k_i^t$, at

[25] Because the voting process, which is present in both the voting and the hybrid treatments, is a non-market way of allocating resources, we would not necessarily expect convergence to competitive equilibria.
[26] Noussair et al. (1995, 1997) used this specification to estimate convergence of experimental international economies. Our analysis expands Noussair et al.'s by allowing different experimental sessions to have different steady-state levels, to explore reliability of convergence across experimental replications.

time *t*. Period *t* is the period number within a horizon, *j* indexes the horizon within a session. $\_{1}$ and B_2 are the coefficients which are estimated from the data. The specification assumes that each horizon's dependent variable value is a period-weighted average of an initial condition value ($\_{1}$, when period *t*=1) and a long-run steady state value $\_{2}$ (the limiting value as t_∞). We call the estimate $\_{2}$ the *convergence value* of the dependent variable for the session. We will say that the dependent variable is converging to a particular level, such as an equilibrium prediction, if the convergence value $\_{2}$ is not significantly different from that predicted level. Since horizons within each session appear to be different, we account for horizon-specific disturbances when estimating convergence levels by including a random-effects disturbance $\_{j}$ for horizon *j*.

Figure 12 plots the maximum likelihood estimates of the convergence values (i.e., estimates of $\_{2}$) for the dependent variables of total capital (x-axis) and total welfare (y-axis) of each of the 21 experimental sessions. Each circle corresponds to estimates from one session. The shaded lines through each point represent the width of 95% confidence intervals on each axis. The dotted lines represent the two steady states. The intersection of the dotted lines in the lower left (bottom) indicates the poverty trap; the intersection of the lines in the upper right (top) indicates the optimal levels of consumption and welfare. [27]

[Insert Figure 12: About here]

Figures 4 and 8 suggested that the baseline economies are unable to emerge persistently from the poverty trap equilibrium. The upper-left "baseline" graph in Figure 12 confirms this impression: All five of the 2-dimensional confidence intervals, extrapolating short-run results to the long-run, include the poverty trap levels for either capital or welfare (the intersection at the lower left of the Figure 12 graph). If the definition of "escaping a poverty trap" is that both the extrapolated capital and welfare levels must be significantly above the poverty-trap levels, then none of these economies has clearly escaped poverty. The

[27] In order to test the relevance of estimating the maximum-likelihood random-effect model, we compared our model to an OLS model using the Hausman specification test. The resulting chi-square statistic was significant at the 5 percent level for 19 out of 21 estimations, where each estimation corresponds to one session. This supports the hypothesis that the maximum-likelihood random-effect model is the better specification for equation (4).

prevalence of poverty traps in the baseline treatment also sets the stage for a possible role of institutions in creating an escape from the poverty trap.

Similarly, the estimated convergence values of capital and welfare for the communication treatment as shown in the upper-right graph in Figure 12, confirm the long-run implication of the observations from the charts of Figures 5 and 9. Two sessions are stuck in the poverty trap, two are close to the Pareto-optimal equilibrium, and two are imprecisely predicted to end up in between the two equilibria.

The estimated convergence values from the voting sessions, shown in the lower left graph of Figure 12, have wider confidence intervals, but only one session appears to be stuck in the poverty trap in the (estimated) long-run. In three of the five sessions, the estimated convergence level of capital (x-axis) includes the optimal steady-state value; at the same time, only one session statistically includes the optimal welfare level. This contradiction between the ability of voting to create optimal levels of total capital accumulation, but welfare significantly below the optimum, is a result of the centralized way in which capital and consumption are simultaneously allocated among agents. Individual behavior in the voting treatment, which is considered in more detail later, provides insights into why capital accumulation can be optimal while welfare lags behind.

The lower-right graph in Figure 12 shows that the hybrid treatment—communication *and* voting—is also variable (as shown by cross-session variability in Figures 7 and 11). However, Figure 12 shows that estimated convergence levels reliably escape the poverty trap in all five sessions. Two sessions, Emory H1 and Emory H2, attain welfare levels that are not significantly different from the optimal steady state.

3.2 Comparison across treatments

To test for differences across the experimental conditions that appear to be evident in Figures 4-11, we performed a very conservative nonparametric rank-sum tests that treat each experimental session as one data point. We used the average value of total output and welfare across periods (to standardize sessions with different numbers of periods[28]) for an entire

[28] Weighting each horizon equally (which effectively gives larger weight to periods in short horizons than periods in long horizons) gives very similar results.

session as the unit of observation. Table 4 shows the (one-tailed) *p*-values from Mann-Whitney rank-sum tests under the null hypothesis of no difference between any two treatments.

[Insert Table 4: About here]

Because there are only 5-6 data points in each treatment, there is only modest statistical power to detect differences across treatments. However, even with this conservative test, we can reject equality of both output and welfare in the baseline versus voting, and baseline versus hybrid, comparisons. The test also rejects equality of welfare in the baseline versus voting and baseline versus hybrid treatments. Thus, voting appears to reliably improve output and welfare statistically, and is often helped along by adding communication.

The aggregate results from the 21 sessions can be summarized as follows. The baseline sessions *never* fully escape the poverty trap. Communication and voting generally improve outcomes. In the hybrid treatment, the economy *always* escapes the poverty trap. The voting process improves the likelihood of escape from the poverty trap, but also distorts the economies by adding variance, which generally hurts capital-accumulation and welfare. Communication in the absence of voting usually clearly points to goals, but is not fully effective at coordinating capital-accumulation to exit the poverty trap. However, as we describe in more detail later, in the hybrid treatment communication improves both voter and proposer decisions. The next section considers the various kinds of inefficiencies that can occur in the economy and compares their magnitude among the four treatments.

3.3 Sources of inefficiencies

Three types of allocative inefficiency can appear in these economies. The first is *output inefficiency*, a lower production level than the highest possible production given the total quantity of capital in the economy. An output inefficiency occurs in a period because the economy's capital at the end of the period is allocated among agents sub optimally (i.e., total output would go up if the agents who have higher marginal products for capital swapped units with other agents who have lower marginal products). We define the output inefficiency as the percentage deviation from the optimal output. Letting $F(\_{i}k_i^t)$ be the maximum possible production with total capital stock $\_k_i^t$ and $\_{i}f(k_i^t)$ be the actual production, the output inefficiency is $(F(\_{i}k_i^t) - \_{i} f(k_i^t))/ F(\_{i}k_i^t)$. In the baseline, voting, communication and hybrid treatments the output inefficiency averages were 39%, 32%, 34%, and 28%, respectively. The hybrid communication-voting rules allocate capital best, but the differences are small. Further experiments could explore the effect of institutions that are better-suited to allocating capital more productively across agents (e.g., more developed capital markets or industrial policies).

A second type of inefficiency is *consumption inefficiency*. The value of a given amount of aggregate consumption is maximized when the units are allocated to agents in a manner that equalizes the marginal utility of consumption among individuals. Let $U(C_t)$ be the optimal level of consumption and $\_v_i(c_i^t)$ be the value of consumption that individual i achieves in period t. Consumption inefficiency is the percentage deviation from the optimal level of consumption and is given by the ratio $(U(C_t) - \_v_i(c_i^t))/U(C_t)$. The average consumption efficiency losses were 4.9%, 6.2%, 6.4%, and 8.6% in the baseline, voting, communication, and hybrid treatments, respectively. Communication and voting did nothing to reduce this type of inefficiency, which also requires a different, possibly institutional, solution.[29]

The third type of inefficiency is *intertemporal inefficiency*, which results from suboptimal allocations to investment and consumption in the economy, given future incentives. Let $V(K_t)$ be the value of the economy's capital stock in period t, assuming that the economy behaves like a benevolent social planner, making optimal decisions from period t onward. This value is an idealized benchmark which assumes the economy from period t onward is directed by a benevolent social planner who chooses aggregate levels and

[29] A reasonable conjecture is that output and consumption inefficiency are due, at least in part, to the fact that individual demand functions, production functions, and endowments were private information. This could mean that the fact that individuals were asymmetric was unknown, and therefore reshuffling of units among them was discouraged. There is, however, evidence from other experiments suggesting that this was not the case. Lei and Noussair (2002) had the same informational structure in similar economies, and they found low average output (1.0%) as well as consumption (2.4%) inefficiency levels. Lei and Noussair (2007) observed an average output inefficiency of 5.4% and a consumption inefficiency of 18.6%. This indicates that high output and consumption efficiencies are possible even when individual incentives and capabilities are private information.

individual allocations of capital and consumption to maximize total welfare. Given this assumption, there is an optimal sequence of capital stock levels from period t on. The market value of a unit of capital under this assumption can be calculated. The market value in period t is equal to the marginal utility of consumption in period t along the economy's optimal trajectory. Let $V(K^*_t)$ be the value of the optimal quantity of capital stock given the current level of output and $V(K_t)$ be the value of the total level of capital generated from the individual agents' actual choices in period t and assuming optimal decisions for the economy thereafter. Intertemporal inefficiency in period t is given by the ratio $(V(K^*_t) - V(K_t))/V(K^*_t)$.

This inefficiency measure shows the largest differences among treatments: 22%, 13%, 12%, and 5%, in the baseline, voting, communication and hybrid treatments, respectively. The hybrid treatment has the lowest intertemporal inefficiency, which implies that both voting and communication are necessary for trading off short-run consumption for long-run investment.[30]

3.4. How do the economies avoid the poverty trap?

In the baseline treatment there were only three horizons in which the capital stock crossed the threshold of 31 (see Figure 4; Emory B3, first horizon and Caltech B2, first and fifth horizons). On the other hand, when both communication and voting are present in the hybrid treatment, the economy consistently surpasses the threshold. This subsection explores the mechanisms that produce a threshold-crossing.

3.4.1. The effect and content of communication

The communication treatment sessions show that exchanging messages facilitates crossing the capital threshold in some horizons, but not in all of them (Figure 5; for example, in Emory C3 and Caltech C1 the economy never surpasses the threshold in any horizon). In general, when the threshold was surpassed for the first time in a session, it followed an exchange of messages in which one agent would suggest that players consume very little or

[30] The chat-room transcripts in both the communication and the hybrid sessions contain no explicit attempts to reduce the output gap or consumption inefficiencies.

nothing, and two or more players indicated agreement. The dialogue in horizon 3 of Emory C2 is a good example of this pattern:

Period 1:
(player 5)>NOBODY CONSUME
(player 1)>DONT CONSUME
(player 4)>lets get this show on the road...move quick
(player 5)>JUST THE FIRST ROUND, ITS WELL WORTH IT
(player 1)>lose a lil...make a lot
(player 3)>HOW
(player 2)>by not consuming

Period 2:
(player 1)>GOOD JOB
(player 4)>well done
(player 5)>THAT A WAY TO DO IT

In that session, four of the five agents endorse holding back consumption in the first period and they do cross the threshold. The subsequent period 2 messages are verbal high-fives.

Dialogue in horizon 2 of Emory C1 is another example, but with less initial agreement:

Period 1:
(player 4)>HOLD K for a round
(player 2)>once again...lets keep all our k...nobody consume this round
(player 4)>is that good player 1 and 5
(player 1)>we say that every round and no body does it
(player 5)>we only have a few min. left
(player 4)>just do it for the first round and we all will have a lot more to use

Period 2:
(player 4)>SEE!
(player 3)>good work
(player 2)>wanna do it again?
(player 3)>let's let it keep growing

Notice that in period 1, after player 4 proposes to "HOLD K" and player 2 provides a seconding vote, player 1 is grumpy and skeptical. But a majority of players *do* hold capital and the aggregate capital crosses the threshold. In the next period, player 2 gloats "SEE!"

Player 3 (who said nothing in period 1) now chimes in and agrees. The economy then stayed above the threshold for the rest of the horizon and session.

To show whether these patterns are typical, Figure 13a displays the capital stock held at the end of each period on the y-axis; the threshold of 31 is the horizontal line. The numbers on the graph are the number of agents who either proposed to keep capital, or agreed with such a proposal, *before* each period. Periods in which the capital stock started below the threshold, then crossed it (or started above the threshold right away), usually coincided with a shift in the number of people agreeing with the proposal to keep capital, from a minority to a majority. For example, in Emory C2, in the second horizon, which lasted only one period, only one agent proposed to keep capital. In the third horizon (the 10th period of the experiment), three people agreed and the capital stock crossed the threshold. When there was never a shift to a majority, the economy never got out of the trap (e.g., the agreement count numbers are only zero or one in Emory C3). Note that majority endorsement of capital accumulation seems to be necessary to cross the threshold, but not sufficient, because there are horizons with majority agreement in which capital accumulation did not result (e.g., Emory C1, horizon 1 and Caltech C1, horizons 1, 4, and 5).

[Figure 13a: About here]

The content of communication is interesting because majority agreement does not *always* result in capital accumulation; studying communication may help us understand why some groups succeed and others fail. We divided the comments into three categories that we felt were most likely to affect behavior: “Don’t consume”, “Keep K (general)”, and “Specific proposal for investment”. The first category consists of proposals suggesting zero consumption for all traders, to build up capital stocks. The second category is a general statement that more capital should be held. The third category includes specific suggestions such as “everyone hold on to 7”, and “everyone try to keep 9-10”. To study which of the categories affect investment behavior, we construct a random effect model. Each period t of a given session is an observation and the data are pooled for all of the sessions in each treatment. The dependent variable is the total number of units of capital K_t allocated for investment in the economy. The independent variables are the total output of the economy in period *t* and dummy variables for the three categories of messages listed above. The dummy variables take on a value of 1 in periods in which the corresponding category of message is articulated and a value of 0 otherwise. Each session and each horizon is assumed to have a random effect.

Table 5 shows the results of the regressions for the communication and hybrid (communication plus voting) treatments. With only communication, proposals to consume zero or which specify exact levels of investment increase average capital stock. Specific detailed messages are more effective than general ones in solving the coordination problem that exists in the communication treatment. Under the hybrid treatment, none of the variables have significant effects on the level of investment. The economy attained high levels of investment without the exchange of substantive suggestions in the hybrid treatment. Having competition between two proposals seems to substitute for more specific communication about what subjects should do, since the proposals themselves are a form of communication.

[Table 5: About here]

3.4.2. The effect and results of voting

Summary statistics about which proposals were elected show mixed success. In both the voting and hybrid treatments, when both proposals forced total capital above the threshold of 31, the one which "cleared the bar" by the least (i.e., minimizing the amount of capital above 31 or equivalently, maximizing consumption) was chosen in 17 of 18 cases. However, when the economy was below the capital threshold and exactly one of the two proposals forced total capital above the threshold (which also means less consumption), the threshold-crossing plan was only elected 12 times out of 21 (57%).[31] This success rate improved to 9 out of 11 (82%) in the hybrid treatment where agents could talk about the proposals.

To further explore what factors determine voting behavior, we take individual voting decision as a unit of observation and identify four independent variables that might influence

[31] The fact that the high-consumption, low-investment plan won 43% of the time is a simple experimental analogue of the difficulty many developing countries have in getting populations to accept fiscal austerity plans which impose short-run hardships but promise long-run development.

voting. The first variable is “higher consumption for the voter;” a dummy variable taking on a value of 1 if the proposal subject votes for gives him more consumption than the competing proposal. This captures the behavior of individuals who myopically favor proposals that give them higher current consumption, which is immediately converted into earnings.

The second dummy variable is “Higher total capital in the economy”, a dummy variable taking on a value of 1 if an individual votes for a proposal that generates a higher level of total investment in the economy. The third dummy variable is “Closer to the myopic optimum consumption.” Define the myopically-optimal consumption as the level that equates the marginal utility of consumption to the expected future price of capital (proxied by the average price in the current period). The dummy variable is 1 if an individual votes for the proposal that yields him a value of consumption closest to the myopic optimum, and equals 0 otherwise.

The variable “More equal investment schedule” is a dummy variable which equals 1 for the proposal that proposes more equal capital for all subjects.[32] That this might be an attractor can be seen, for example, in many communication transcripts, in which subjects proposed that all agents hold 7 units of capital stock. The fourth variable is “Vote for my own proposal”, a dummy variable taking on a value of 1 if the individual voted for a proposal that he submitted himself, and zero otherwise. It is reasonable to expect that those who propose an investment schedule would want their own proposals to be implemented.

We use a random-effects logit model to estimate the coefficients, incorporating both horizon-specific and session-specific disturbances. The dependent variable equals 1 when a subject votes for proposal number 1 and 0 otherwise. Table 6 displays the results. The results in both the voting and the hybrid treatments show that “Higher consumption for the voter” and “Vote for own proposal” are the only factors that reliably explain voting decisions.

[Table 6: About here]

[32]Note that an equal capital investment schedule does not yield equal earnings, since subjects have different utility and production schedules. Equal investment might have coordinating power however, since it is simple and because subjects do not know the utility and production values of others subjects.

Together, these data show that agents are naturally inclined to vote for plans with more consumption (and hence less investment); as a result, they do not always vote for the "fiscal austerity" plan that limits consumption in order to clear the capital-stock threshold.

While voting generally improved efficiency, there is also some evidence that determining investment purely by voting over proposals increased economic volatility. In each of the voting and hybrid treatments, there were two horizons in which the economy surpassed the threshold, then later fell below it, during the same horizon. This *never* happened in the treatments without voting.

Voting seems to work because the individual agents who made proposals showed a lot of rationality and restraint in how much consumption they proposed for themselves. Only 25% of the time, is the proposed own-consumption above the *myopic* optimum level.[33] Proposers also do not favor themselves over others. The consumption they propose for themselves is higher than for all of the other four agents only 22% of the time, and higher than the proposed group average only 48% of the time (With no favoritism, the latter figures would be 20% and 50%.). In this simple setting, either altruism or political competition between the two proposals is enough to restrain the proposers' self-interest. This could be studied further by restricting competition—e.g., a dictator makes a single proposal, or after a proposal is elected the winning proposer becomes an incumbent with no competition for several periods.

3.4.3 Interactions of communication and voting in the hybrid treatment

In the hybrid treatment with voting, communication did not follow the same pattern as in the communication-only treatment. In only 6 of 15 instances, in which the threshold was surpassed, was there majority agreement to increase the capital stock during the pre-voting communication. Figure 13b shows the time series of capital stock and the number of agents who proposed or agreed to keep capital. A majority agreement is not necessary to cross the threshold, in contrast to in the communication treatment, shown in Figure 13a. The voting process therefore appears to be, to some extent, a substitute for communication in

[33] All of the statistics reported in this paragraph are almost identical between the voting and the hybrid treatments.

coordinating a collective threshold-crossing decision. When there is voting on proposals, agreement is not needed to reduce strategic uncertainty because a single enforceable proposal can do the job of verbal agreement.

Adding communication substantially raised the number of proposals which planned to cross the capital-stock threshold in the right direction. When the economy was above the threshold in the previous period, 33% of the voting-only proposals would pull capital *below* the threshold, compared to only 17% in the hybrid case. When the economy was below the threshold in the previous period, only 36% of the voting-only proposals would push capital above the threshold, compared to 69% in the hybrid case. Pre-proposal communication is therefore very helpful in generating more proposals that create transitions in the right direction across the total capital threshold, and in avoiding transitions in the wrong direction. Communication also appears to constrain selfish proposer decisions that harm the group. Without communication, 8.3% of all proposals (18 in total) proposed a plan in which the proposer would consume more than his or her myopic optimum, and total capital would end up *below* the threshold. These proposals impose a big drain on the economy (including the proposer's own future consumption). Such proposals were much more rare (3 cases, 2% of the total) in economies with both voting and communication.

[Figure 13b: About here]

4. Conclusion

In this paper we introduce a laboratory methodology for studying the effect of institutions on economic growth. In the experiment reported here, we focus on one of the many possible specific sources of low growth, a lack of coordination of investment activity. We create an economy in which such a coordination failure can cause the economy to find itself in a poverty trap. We then consider whether two particular political economy institutions facilitate avoidance or exit from the poverty trap. We focus on extremely simple versions of the institutions—free expression, in the form of open *communication* before investment occurs, democratic majority-rule *voting* on binding proposals for how output is divided between consumption and investment, and a *hybrid* combination of communication and voting.

We find that the right to make announcements, as captured in our communication treatment, allows the coordination of investment to occur in some groups, but not others. For the groups in which the productivity threshold is surpassed, the decentralized consumption and investment decisions allow the economy to converge to close to its optimal steady state. Three of the six economies with an identical structure operate close to their optima, while the other three remain close to the poverty trap levels of output and welfare. These differences illustrate that some economies may be more successful than others purely because different individuals are populating them, since their parametric and institutional structure is identical. Majority agreement and specific messages seem to mitigate coordination failure.

The voting process also provides a mechanism for coordination, as the policy proposals are binding on all agents. Competition between proposals appears to restrain self-interest. However, although voting often allows the capital threshold to be surpassed, the centralized intervention into consumption and investment decisions creates volatility from one period to the next, and impedes the process of convergence to the optimal steady state. The data illustrate that, unlike what is often the case with market competition, political competition can achieve good outcomes for voters with a small number (two) of competitors. It also shows that, while an institution such as voting of the type we study here may be a good remedy for one specific source of low growth, coordination failure, it does not appear to improve suboptimal activity from other sources, such as inefficiencies in the allocation of consumption or productive assets. Different institutional solutions appear to be required to address different causes of inefficient economic activity.

In the hybrid treatment, output and welfare are the highest of the four treatments, and in no session does the economy fall into the poverty trap. In a sense, voting and open communication go "hand in hand" in resolving the coordination problem our economies face. Communication enhances the quality of proposals because it permits debate about what proposals might be beneficial. Voting enhances the effect of communication because it resolves the strategic uncertainty inherent in the decision whether to commit oneself to restrict one's own consumption in response to others' suggestions to do so, when such suggestions are cheap talk.

The punchline of the paper is that decentralized economies of this sort do tend to get stuck in poverty traps, but combinations of communication and voting help them escape the poverty trap. Figure 12 shows that there is no baseline case in which the group fully escaped the poverty trap, and there is no hybrid (communication and voting) group which got stuck in the poverty trap.

These inferences are obviously specific to this modest sample of economies with the particular structure we have studied here. Further research is required to explore the robustness of these results to differences in economic structure and scale, as well as the characteristics of agents that populate the economy. The institutions we have studied are readily scalable to economies with a much greater number of agents and can be applied in economies with different structures.

There are many directions for future research. Some questions emerge directly from the results reported here. Voting seems to work well here to restrain the proposers' self-interest, but is this due to competition between two proposers, to fear of sanctions, or to proposer altruism or social responsibility? Voting also generates more volatility, with economies slipping below the productivity threshold at times; can including more proposers or different voting systems dampen this volatility? If certain kinds of messages facilitate growth, can we cause growth reliably by exogenously transmitting these messages? Answers to questions like these are within our grasp with more experiments of this type.

Another interesting class of institutions is those that aggregate opinion (such as prediction markets), and these might also improve coordination. For example, Forsythe, Palfrey and Plott (1984) found that opening futures markets improved the ability of spot markets to aggregate information about differences in values. In our design, one could add a prediction market in which individuals trade claims in each period based on whether the total capital K is above or below $\hat{K}$ in future periods. It is possible that such markets could express publicly-observable collective optimism that in the future K would be above the threshold (if the price of the $K \geq \hat{K}$ claim is high). If that claim trades at a high price, it could encourage agents to invest, and fulfill the prophecy expressed by the high claim price. Of course, this process could also work to keep agents even more stuck in the poverty trap, if a pessimistic expectation is expressed by a high price on the claim $K < \hat{K}$.

Finally, our dynamic environment is general and flexible enough to be used as a benchmark to study situations where a small group of agents jointly require multi-period restraint in their consumption behavior. Capra and Tanaka (2006), for example, have used a similar structure to study the extraction of natural renewable resources such as fisheries, where the stock of the resource determines its growth rate, and multiple equilibria can exist. The small scale of these experiments means they may also be directly applicable to groups or organizations in which several actors, such as managers, make capital allocation decisions, and there are breakthroughs in productivity if enough managers coordinate investment. Then, the influence of open debate and formal voting over two proposals can be interpreted as a test of which organizational practices enhance productivity.

Our design can also be readily modified to include many other features of interest to macro-and development economists, such as incomplete property rights, unequal wealth and income distribution, or regulatory policy options, such as taxation and redistribution. Different political systems such as dictatorship, indirect democracy, socialism, and anarchy can also be compared. Institutions that are successful at producing wealth in one environment can be unpacked and implemented in a different environment to test their robustness. In addition, in the laboratory, the study of institutions need not be restricted to ones that naturally occur. Indeed, new institutions that theory, economic intuition, or prior experimentation suggest may be effective, can be designed, constructed, inserted into the experimental economy, and studied.

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Table 1: Parameters of the model

$U(C_t)$: economy-wide utility function	$400C_t - 2C_t^2$
$F(K_t)$: economy-wide production function	$AK_t^{0.5}$
A: production-efficiency parameter	$\underline{A} = 7.88$; if $K_t < 31$ $\overline{A} = 16.771$; if $K_t \geq 31$
$\hat{K}$: threshold level of capital stock	31
ρ : discount rate	0.25
δ : depreciation rate	1

Table 2: Values of variables in equilibrium

Variable	Optimal Steady State	Poverty Trap
Capital (K)	45	9
Consumption (C)	70	16
Price (P)	118	334
Welfare (U)	18,060	5,856

Table 3: Session information for all treatments

Treatment	Date	# of horizons	# of periods per horizon, h: (h1, h2, h3, …hi)	Avg. earnings in Yen	Avg. earnings in $[§]
Baseline					
Emory B1	03/22/04	5	(4, 7, 2, 2, 7)	25,343	39.24
Emory B2	03/24/04	6	(3, 3, 7, 2, 1, 4)	23,801	36.84
Emory B3	04/07/04	6	(5, 2, 1, 3, 4, 4)	28,678	47.26
Caltech B1	07/08/04	4	(4, 4, 7, 6)	22,274	34.80
Caltech B2	07/12/04	6	(2, 3, 3, 2, 3, 1)	17,007	26.87
Communication					
Emory C1	03/22/04	2	(7, 7)	19,848	16.06
Emory C2	03/23/04	5	(8, 1, 3, 5, 2)	27,607	23.57
Emory C3	04/01/04	4	(3, 7, 6, 4)	23,458	19.26
Caltech C1	07/15/04	5	(6, 1, 1, 2, 4)	14,219	11.56
Caltech C2	07/19/04	5	(3, 4, 1, 3, 6)	33,060	28.64
Caltech C3	10/07/04	4	(11, 2, 5, 2)	52,170	44.24
Voting					
Emory V1	03/24/04	4	(11, 5, 3, 3)	36,767	31.05
Emory V2	03/27/04	6	(6, 2, 1, 2, 5, 5)	25,750	21.86
Emory V3	04/01/04	5	(1, 5, 1, 7, 4)	37,355	32.27
Caltech V1	07/13/04	7	(6, 2, 4, 2, 1, 3, 5)	35,963	30.85
Caltech V2	07/14/04	8	(3, 4, 8, 2, 1, 3, 1,2)	31,330	25.66
Hybrid					
Emory H1	06/01/04	2	(4, 6)	17,202	27.15
Emory H2	09/01/04	3	(8, 2, 4)	23,102	18.74
Emory H3	09/01/04	4	(4, 4, 7, 4)	37,190	31.27
Caltech H1	08/03/04	5	(5, 8, 2, 2, 2)	48,015	42.66
Caltech H2	08/04/04	3	(2, 9, 2)	22,045	18.72

[§] = Conversion rates of experimental currency into US dollars differed depending on the treatment and player's role. See section 2.3.6.

Table 4: P-values for rank sum tests of differences in output and welfare between treatments

Output			
	Communication	Voting	Hybrid
Baseline	0.164	0.016	0.004
Communication		0.214	0.214
Voting			0.155
Welfare			
	Communication	Voting	Hybrid
Baseline	0.214	0.016	0.004
Communication		0.214	0.123
Voting			0.048

Note: P-values are for one-tailed rank sum tests. The alternative hypothesis is that values of output or welfare for the treatment listed in the column are *larger* than values for the treatment listed in the row. Therefore, a *low* p-value means the row treatment produces *lower* numbers than the column treatment.

Table 5: The Effect of Communication Content on Capital Stock Level, Results of Random-effect GLS Estimation

Dependent Variable = Economy-wide Capital Stock Level

(Communication)	R^2(overall)=0.86		
	Estimated coefficient	Std Error	p>|z|
Total K in the Economy	0.46	0.02	0.00
Don't Consume	6.99	2.28	0.00
Keep K (general)	1.13	2.18	0.61
Specific Proposal	4.32	2.53	0.09
Constant	1.71	1.50	0.25
(Hybrid)	R^2(overall)=0.54		
	Estimated coefficient	Std Error	p>|z|
Total K in the Economy	0.34	0.04	0.00
Don't Consume	8.02	7.04	0.25
Keep K (general)	-5.12	3.37	0.13
Specific Proposal	-5.95	4.46	0.18
Constant	14.87	3.96	0.00

Table 6: Influences on voting decisions, Random-effects logit estimation
Dependent Variable = 1 if Individual Votes for Proposal, and = 0 otherwise

Voting Sessions	Estimated coefficient	Std Error	p>|z|
Higher own C	0.62	0.23	0.01
Higher total K in the economy	-0.07	0.23	0.75
Closer to the myopic optimum C	0.00	0.02	0.91
Equal investment	0.13	0.20	0.51
Vote for own proposal	2.69	0.36	0.00
Constant	-0.80	0.30	0.01
Hybrid Sessions			
Higher own C	0.68	0.24	0.01
Higher total K in the economy	-0.02	0.26	0.95
Closer to the myopic optimum C	-0.02	0.02	0.29
Equal investment	-0.34	0.25	0.18
Vote for own proposal	1.32	0.28	0.00
Constant	-0.26	0.33	0.44

Figure 1: Individual Production Functions

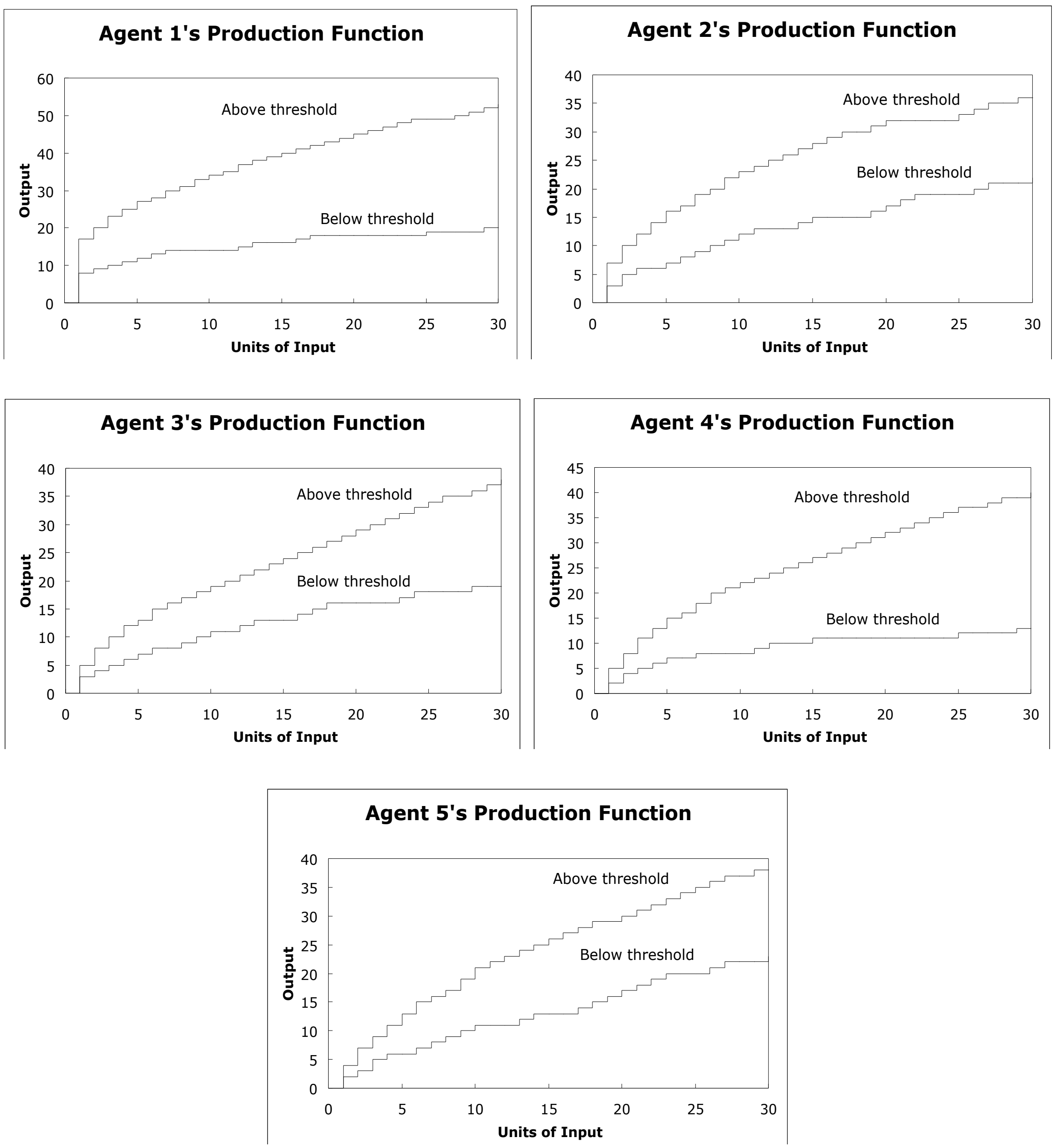
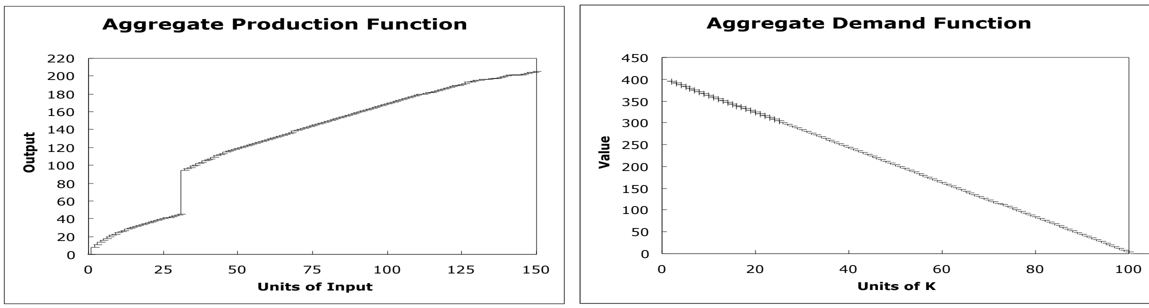


Figure 2: Aggregate Production and Demand Functions, discontinuous increase in input-output productivity when aggregate capital stock reaches 31.



Figures 3a-3d: Timing within a period

Figure 3a: Baseline

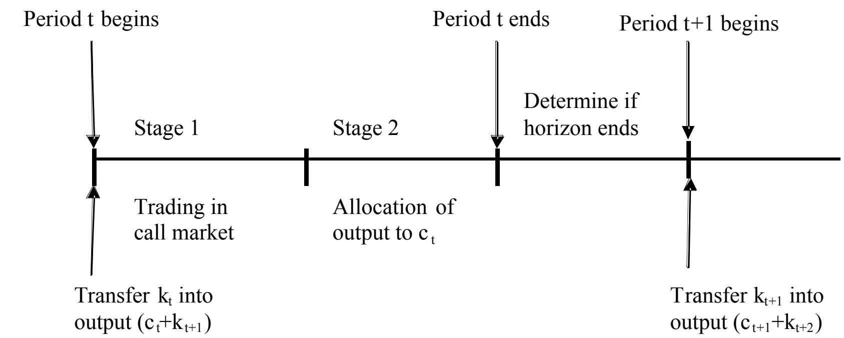


Figure 3b: Communication

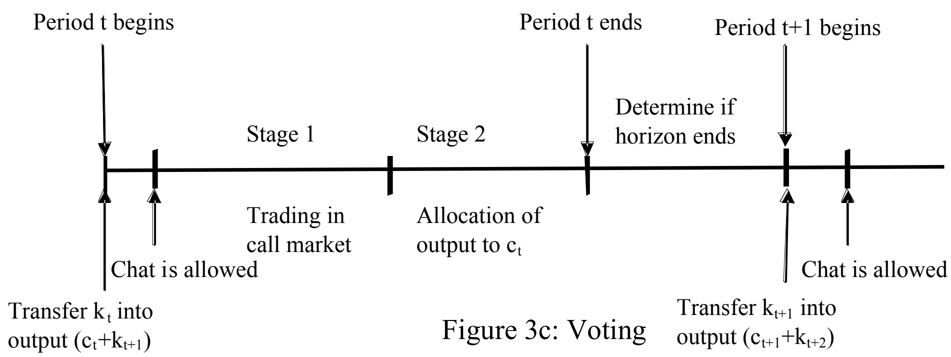


Figure 3c: Voting

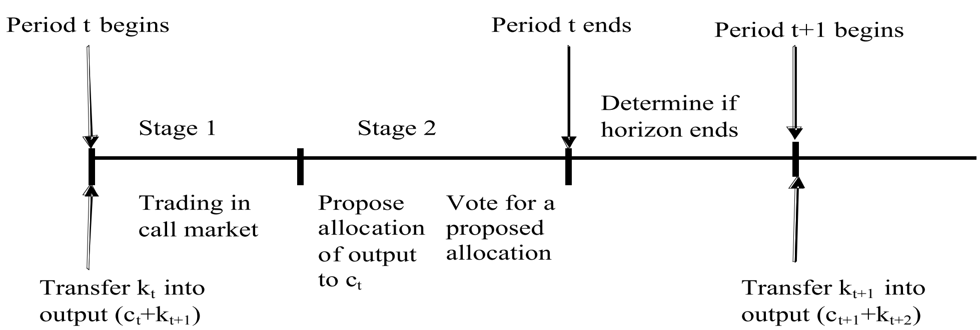


Figure 3d: Hybrid

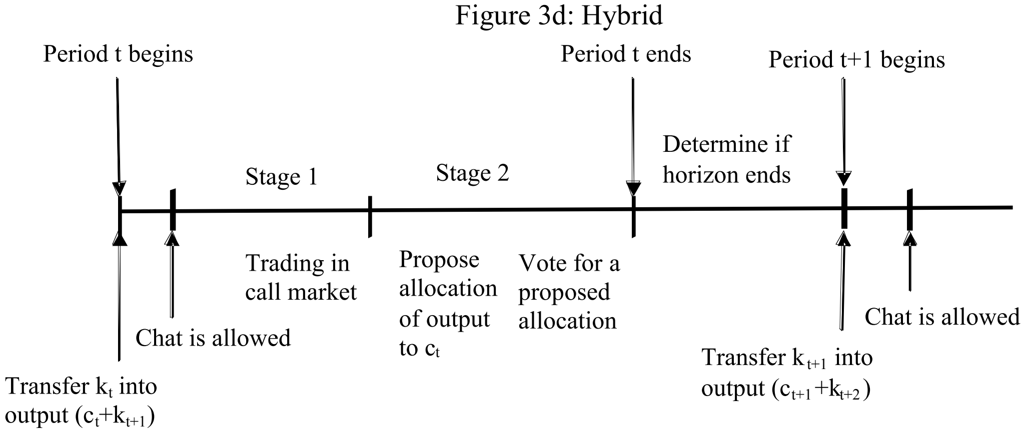
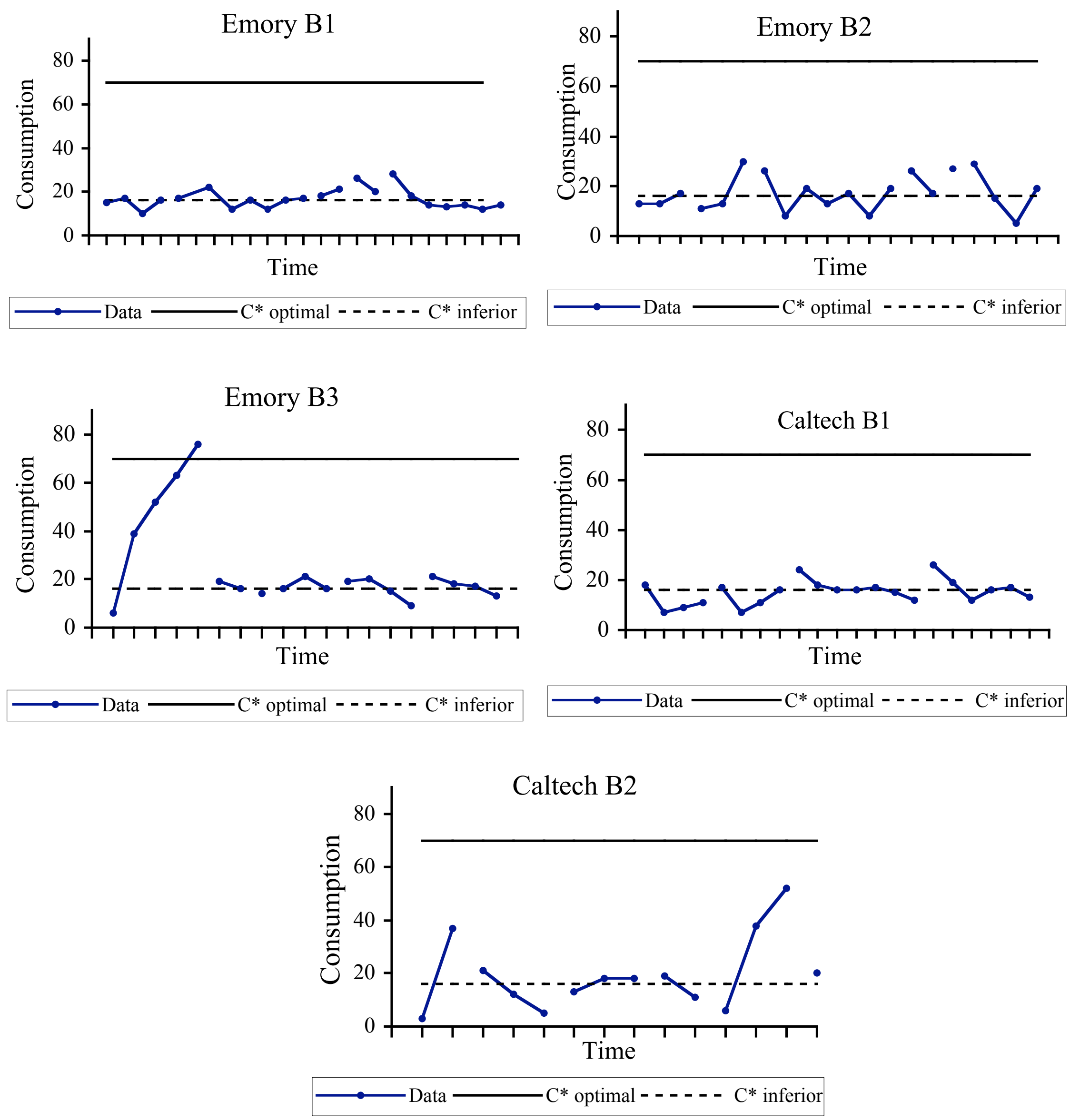


Figure 4: Observed and Equilibrium Aggregate Consumption, *Baseline Treatment,* C* optimal = 70, C* inferior = 16§



§= Each data point represents a period in a horizon. Horizons are separated by spaces. For instance, in Emory B1 the first horizon had four periods.

Figure 5: Observed and Equilibrium Aggregate Consumption, *Communication Treatment*, C* optimal = 70, C* inferior = 16

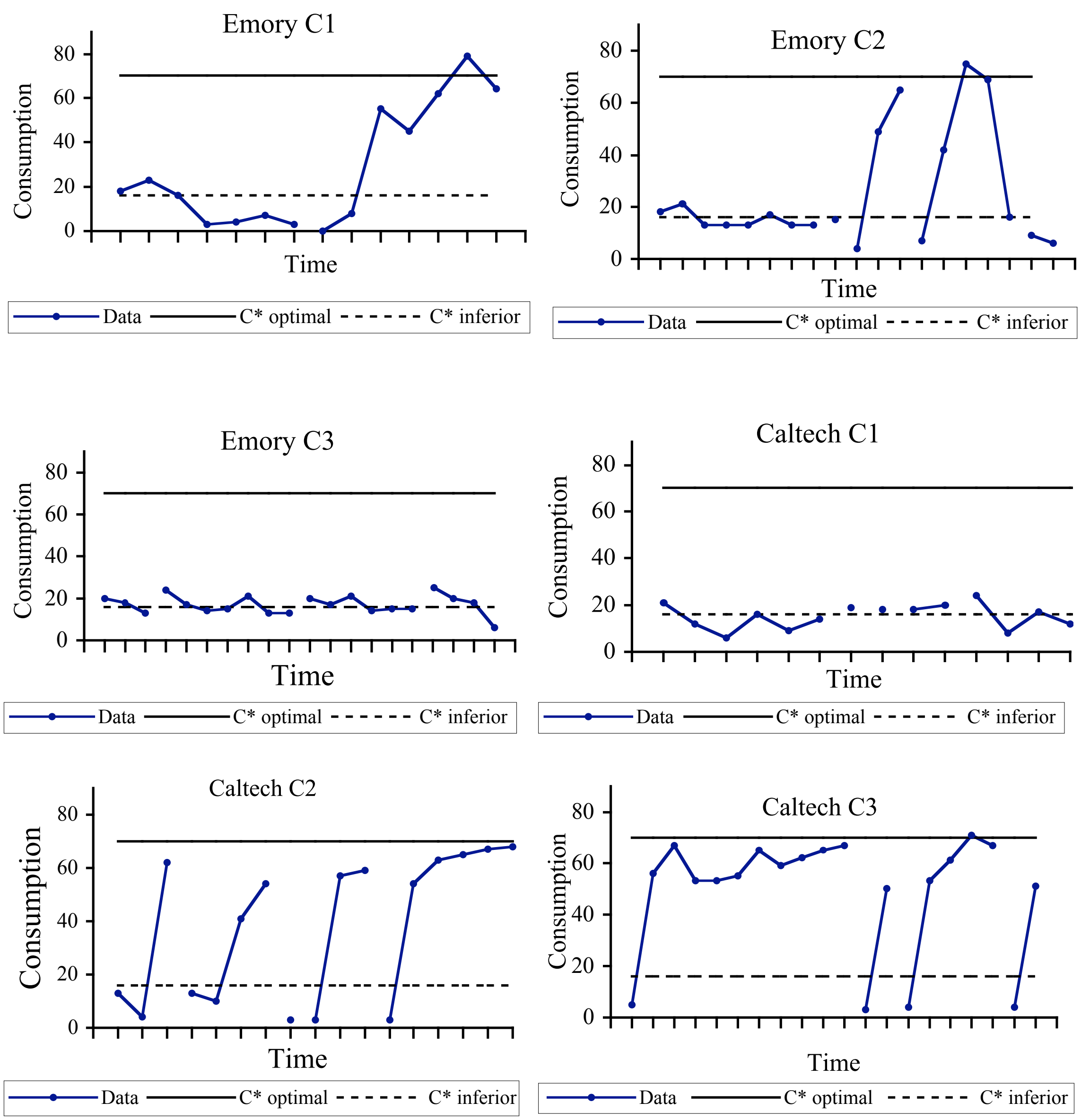


Figure 6: Observed and Equilibrium Aggregate Consumption, *Voting Treatment*, C* optimal = 70, C* inferior = 16

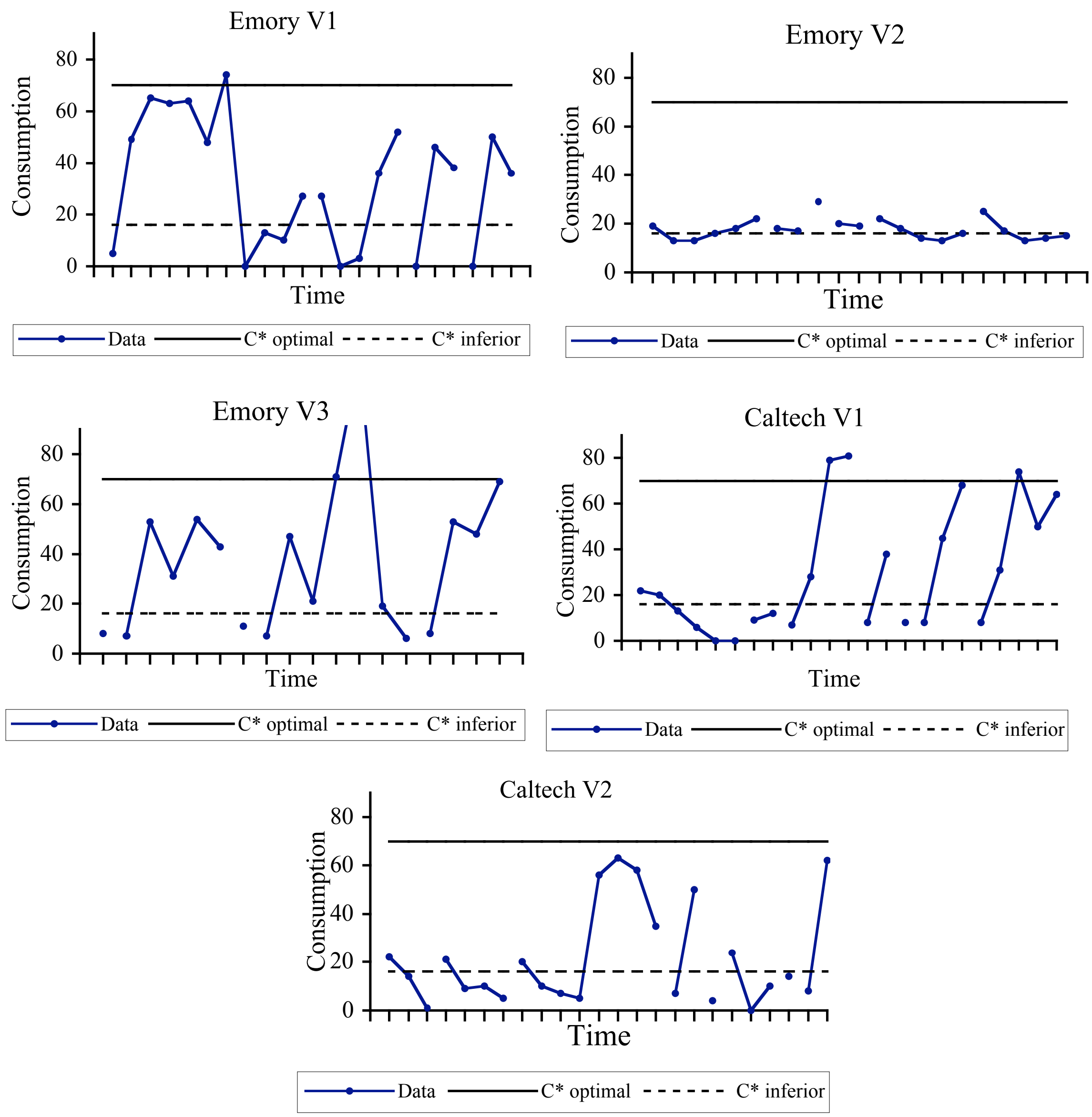


Figure 7: Observed and Equilibrium Aggregate Consumption, *Hybrid Treatment*, C* optimal = 70, C* inferior = 16

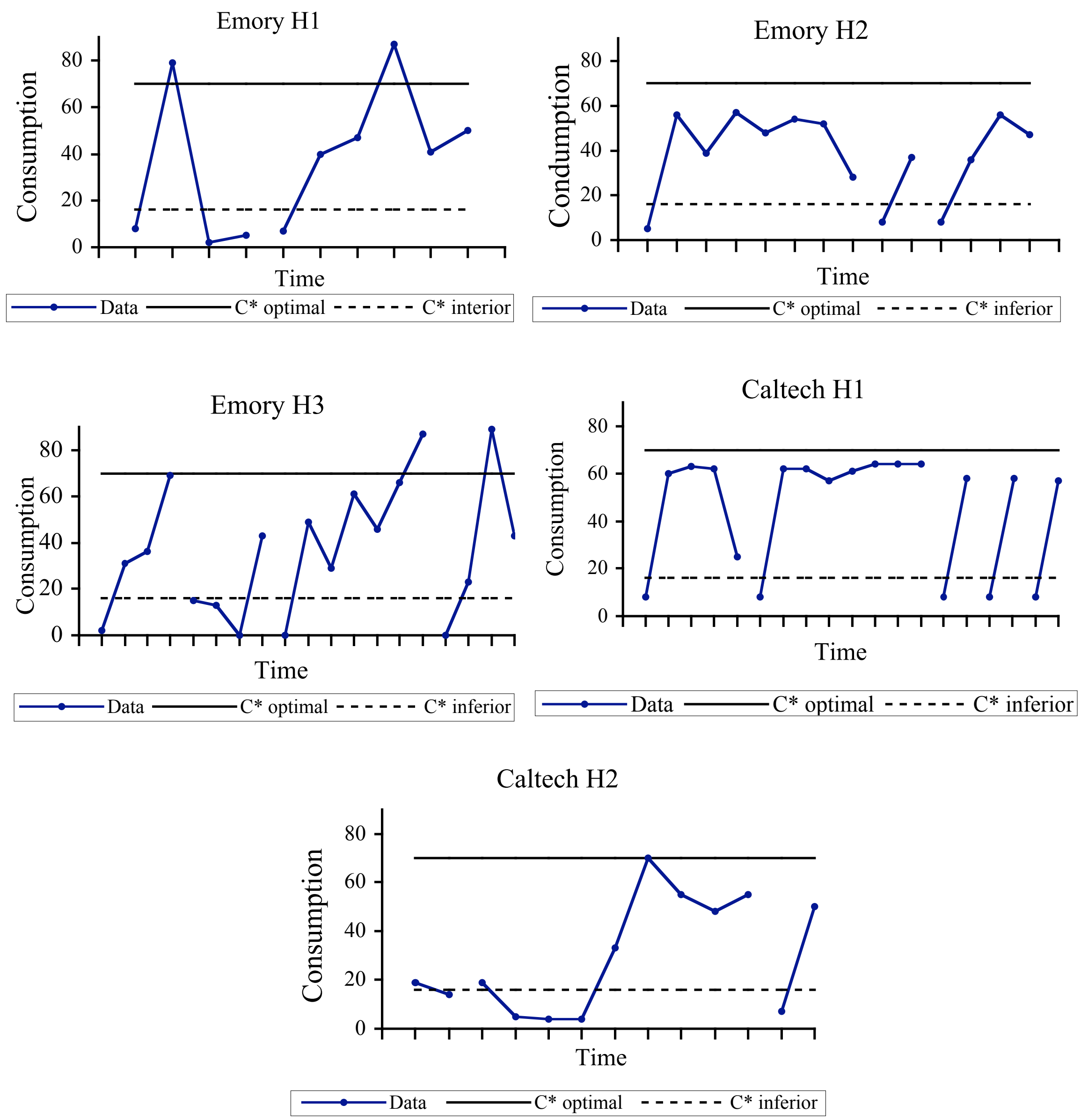


Figure 8: Observed and Threshold Level of Aggregate Capital, *Baseline Treatment*

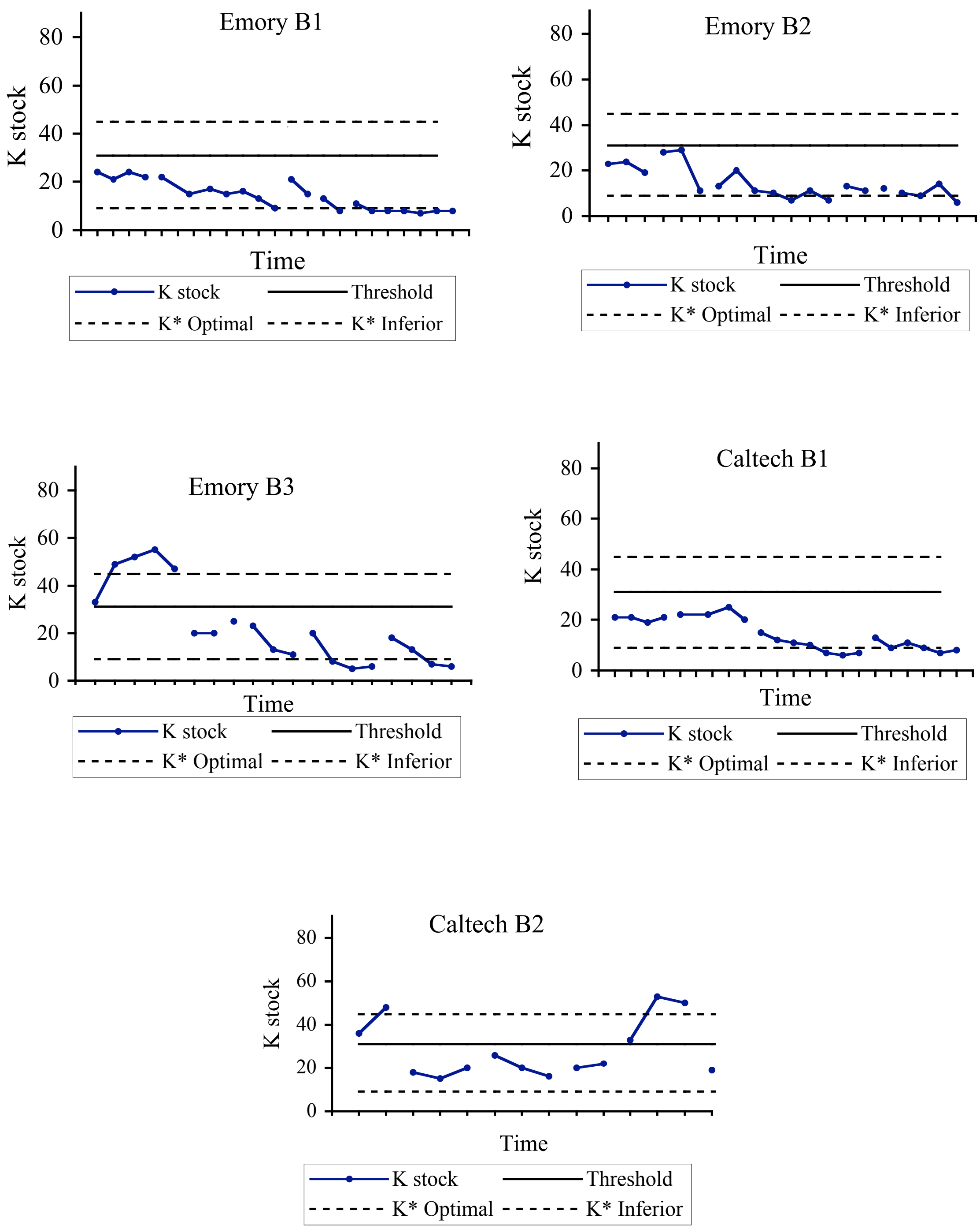


Figure 9: Observed and Threshold Level of Aggregate Capital, *Communication Treatment*

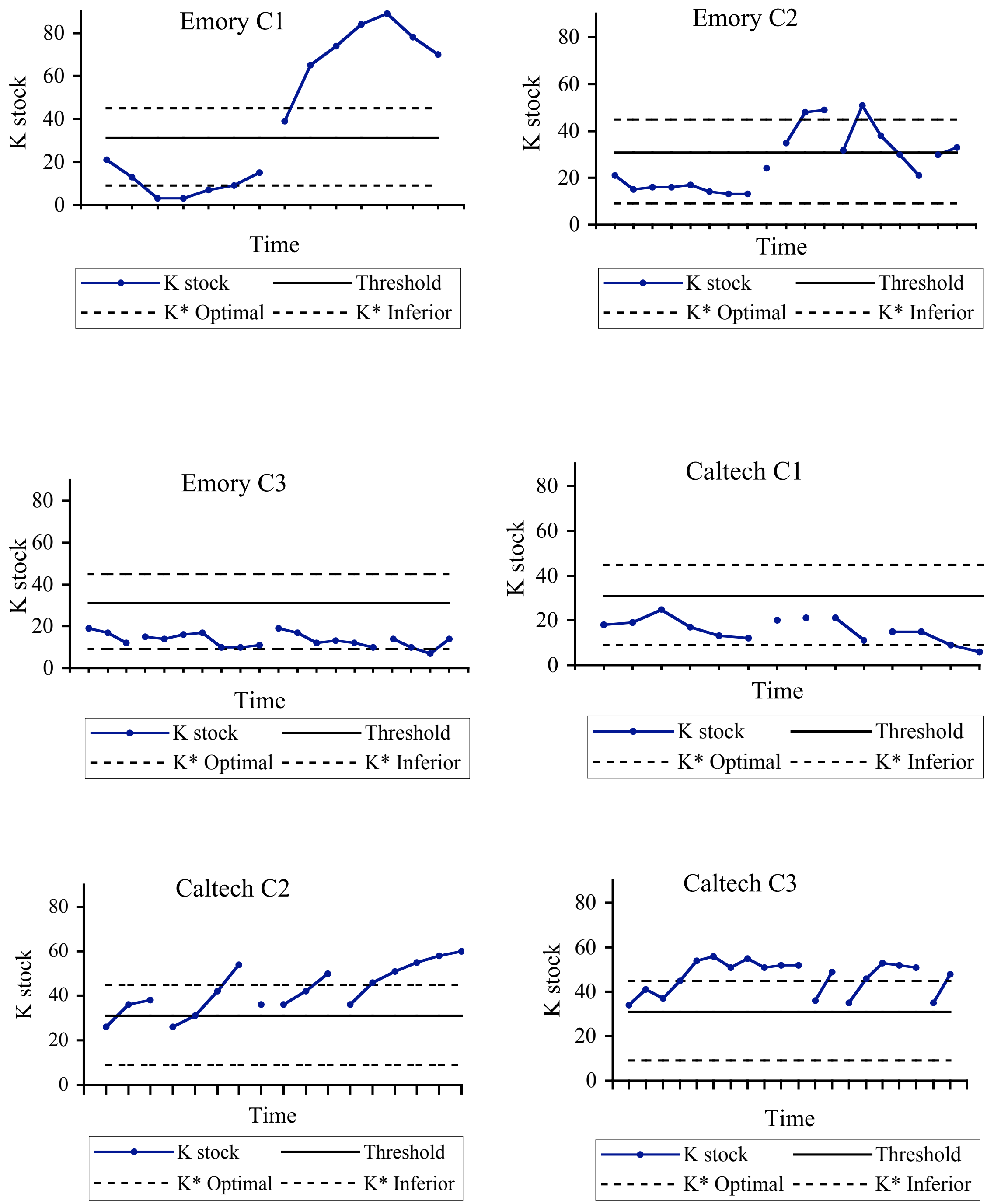


Figure 10: Observed and Threshold Level of Aggregate Capital, *Voting Treatment*

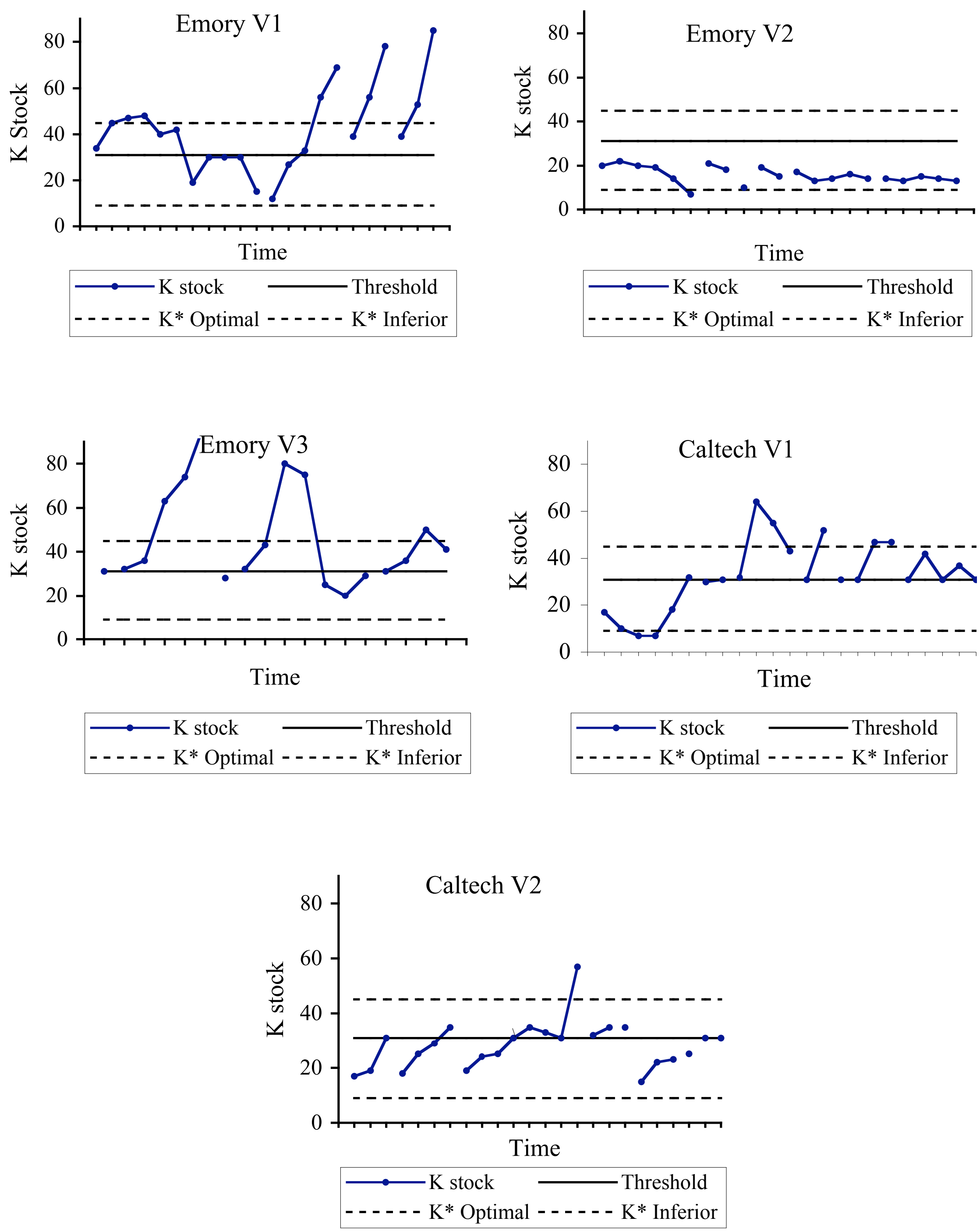


Figure 11: Observed and Threshold Level of Aggregate Capital, *Hybrid Treatment*

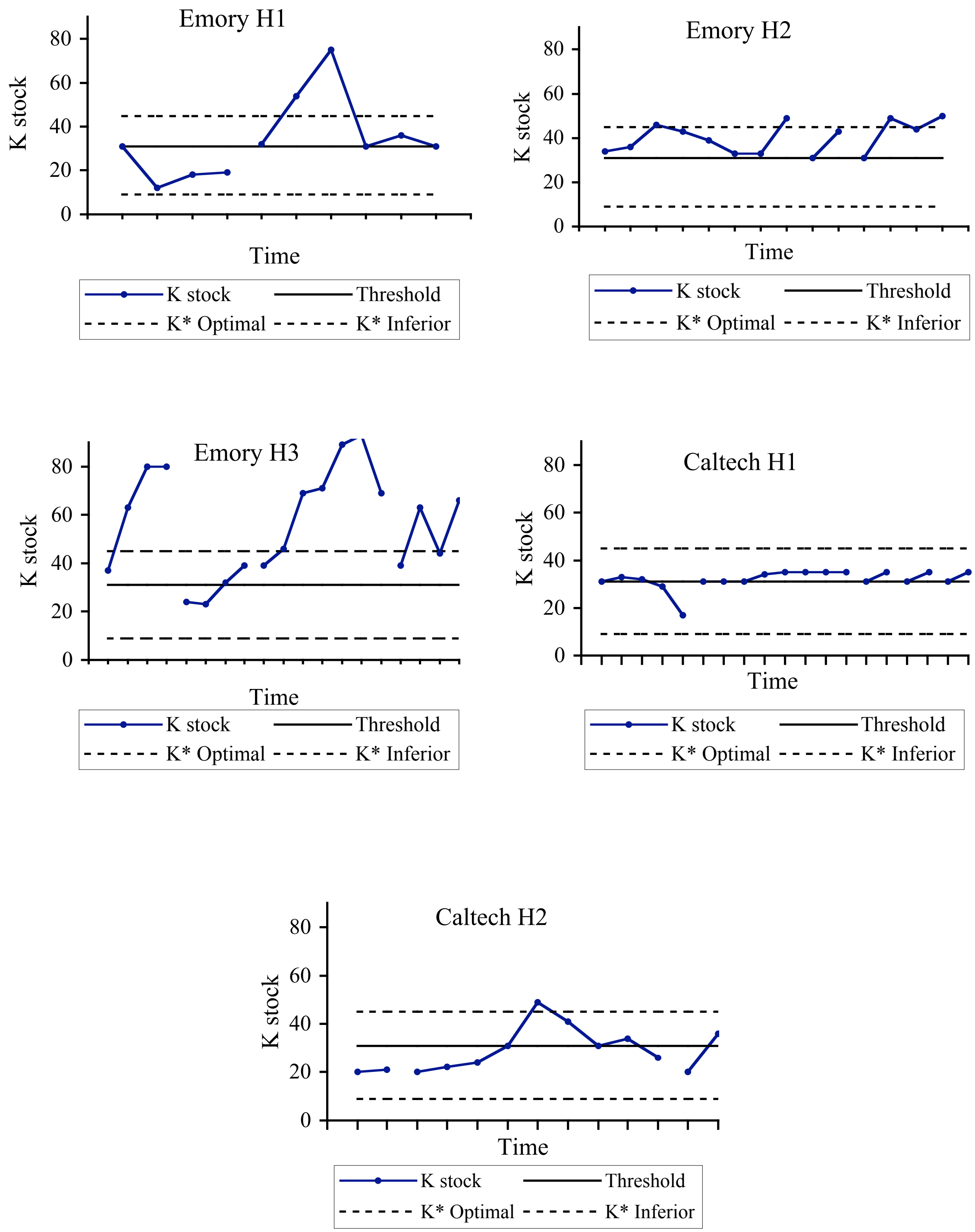


Figure 12: Convergence Values and 95% Confidence Intervals for Capital Stock and Welfare, *All Sessions*

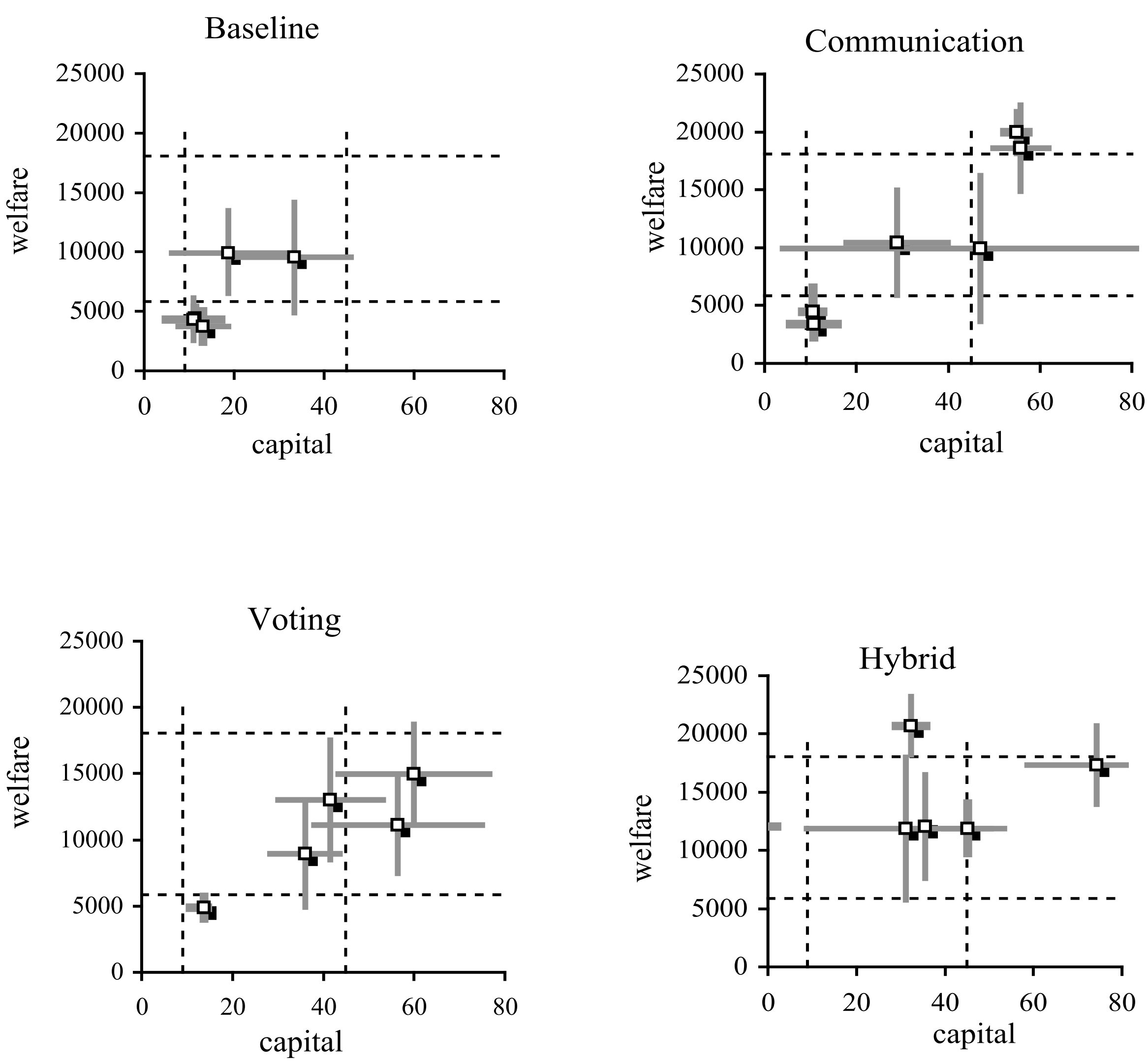
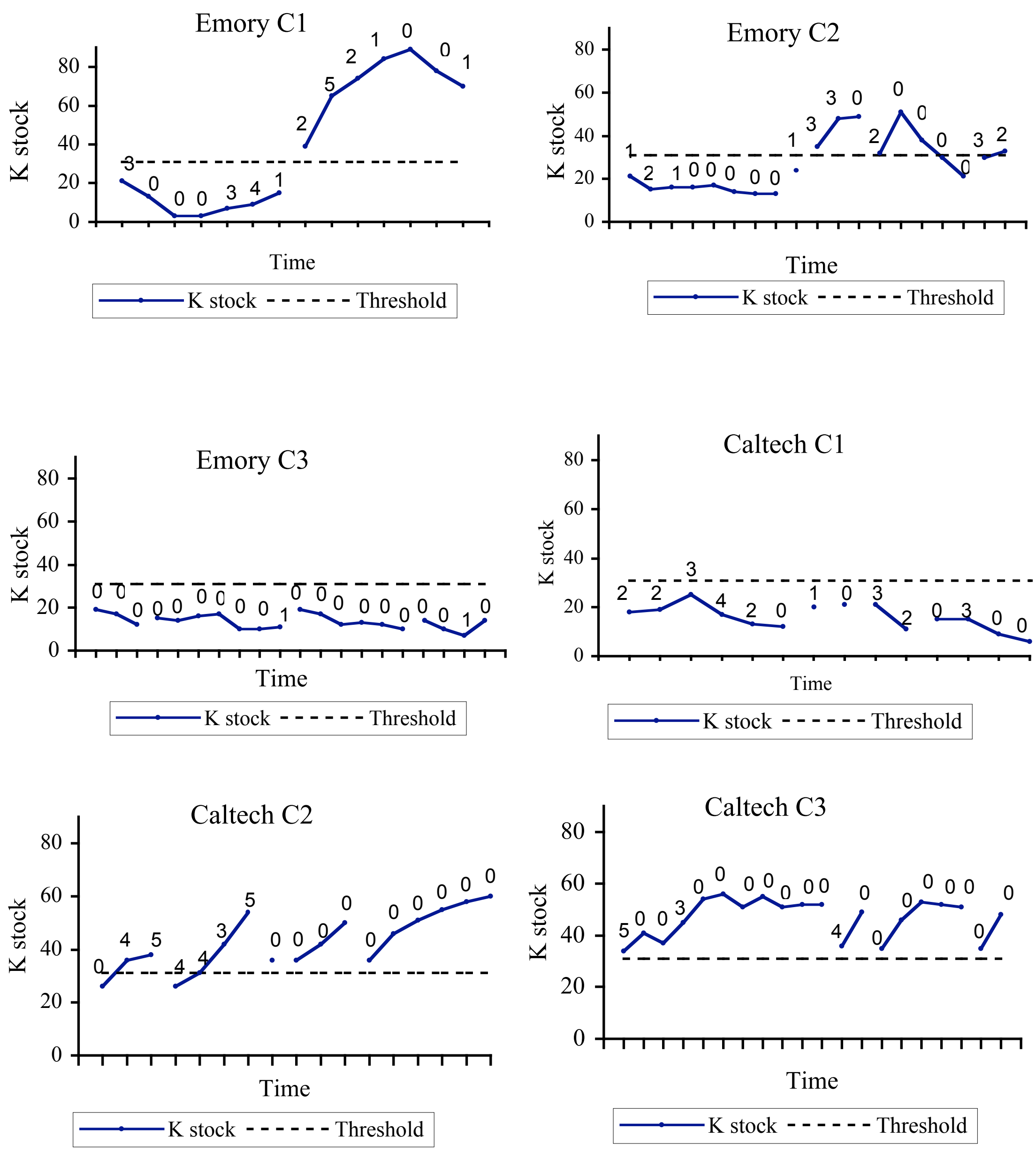
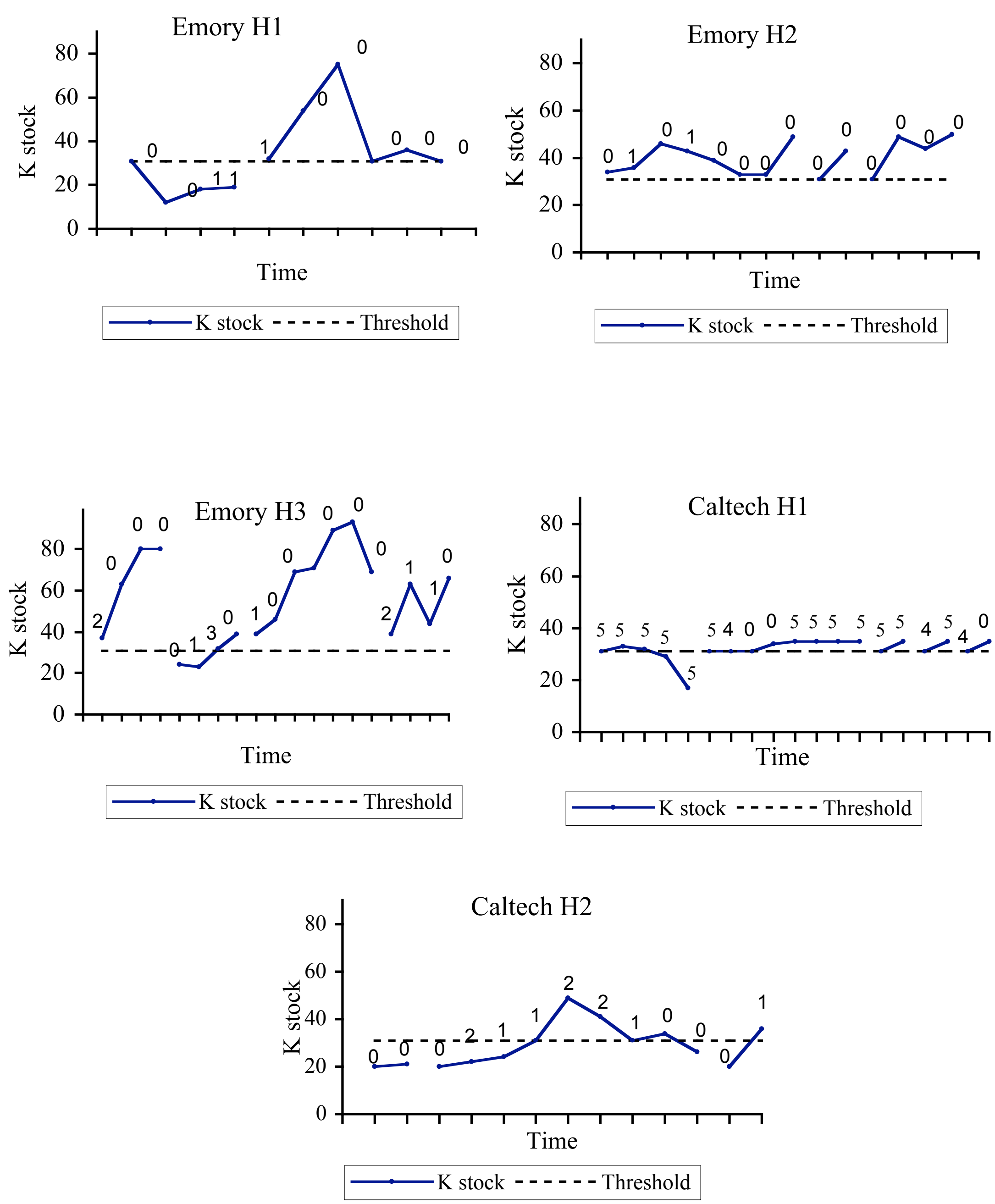


Figure 13a: Economy's Capital Stock and Number of Agents Communicating a Willingness to Coordinate Investment, *Communication Treatment*



Figures 13b: Economy's Capital Stock and Number of Agents Communicating A Willingness to Coordinate Investment, *Hybrid Treatment*



The remainder of this document contains the instructions for all four treatments of the experiment to aid the referees and editors in evaluating the manuscript. The instructions for communication excluded the voting sections and the instructions for voting only excluded the communication section. The baseline treatment excluded both communication and voting. Instructions for all treatments are available upon request.

Please note that this material is not intended for publication.

>>>>>>>>>>>>> Baseline Treatment <<<<<<<<<<<<<<<

INSTRUCTIONS FOR EXPERIMENT

1. General Instructions

This is an experiment in the economics of decision-making. The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The amount of payment you receive depends partly on your decisions, partly on the decisions of others, and partly on chance. The currency used in the market is Yen. All trading will be in terms of the Yen. The cash payment to you at the end of the experiment will be in US dollars. The conversion rate is _____ Yen to 1 US dollar.

Once the experiment has started, no one is allowed to talk to anybody other than the experimenter. Anyone who violates this rule will lose his or her right to participate in this experiment. In addition to your earnings from the activity in the experiment, you will receive a …… payment for your participation.

2. Basic Concepts

The experiment will consist of a sequence of periods. At the beginning of each period, you will begin with a Cash Endowment of ______ Yen. You will also be given _____ units of a good called K on a one-time basis at the beginning of the first period of the experiment.

In each period, there will be an open **market**. You will use this market to buy and sell units of K. Buying units of K reduces your cash by the amount of Yen that you pay for your purchases, whereas selling increases the cash you have by the amount that you receive for your sales. Thus, selling and buying K determines in part the earnings you make in each period.

In addition, you will have a chance to choose how many units of K to **consume**. How much of K you consume during a period will also in part determine your earnings for the period. The K you do not consume can grow and can be sold or consumed in future periods.

Your **earnings** in a period are equal to **the amount of cash you have after buying and/or selling K minus the cash you began the period with, plus the earnings you receive from the consumption of K**. A detailed explanation of how to buy, sell and consume units of K is given later on in these instructions.

Each period is divided into stages. In stage 1, you can buy and sell units of K. In stage 2, you decide how much to consume. In stage 3, the K you have is converted to a different quantity of K that you begin the next period with.

3. Stage 1: Buying and Selling Units of K

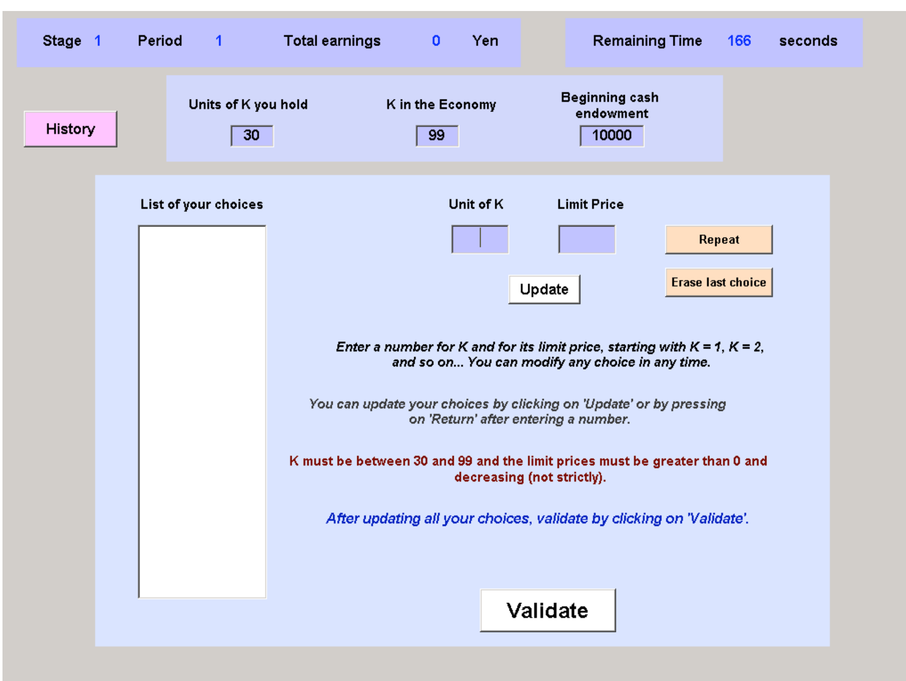
The picture shown below is a copy of the first screen that you will see during Stage 1 of each period of the experiment. At the top of the screen you can find the *Period* number, the *Total Earnings* you have in *Yen* and the *Remaining Time* in *seconds* that you have to complete Stage 1. Below this information, you will find the number of *Units of K You Hold*, indicating the number of K that you currently have. You will also find the *Units of K in the Economy*, which is the total K that all five players currently have. You will also see the *Cash Endowment* for the period, indicating how much cash you currently have available for transactions.

3.1 Sending in Limit Prices to the Market

You will use this screen to indicate the number of units of K you want to trade. You do so using the spaces *Units of K* and *Limit Price*. Under *Units of K*, you must enter a series of numbers in an increasing manner. The numbers will appear in the large window on the left portion of the screen. Type in a 1 for the first row, a 2 for the second row, a 3 for third row, etc… Enter as many numbers as the most units of K that you are willing to hold. The minimum quantity of units you can list is equal to the number of K you currently hold, the maximum quantity of units you can list is equal to the number of units in the economy.

In the *Limit Price* field you must enter a **limit price** for each unit you list. The role of limit prices will be explained shortly. Each unit number must be accompanied by a limit price for the unit. The limit price will also appear in the large window on the left portion of the screen. Enter the limit price next to its corresponding unit. For example, if you enter 500 next to unit 1, it means that your limit price for the first unit is 500. If you enter a limit price of 450 next to the 2nd unit, it means that your limit price for the second unit is 450, and so on.

The limit price for each additional unit must be less or equal to the previous one. For example, if you list a limit price of 123 Yen for the first unit, the second unit's limit price must be equal or less than 123 Yen; similarly, the third unit's price must be less or equal to the second unit's price. All prices must be greater than zero. After entering a unit number and its corresponding limit price, you must click on *Update*; you will see your choices recorded in the column entitled *List of your choices.* At any time you can modify your choice. You can also select the keys *Erase all choices*, which clears all of your limit prices, *Erase last choice*, which will remove the limit price for the highest numbered unit, and *Repeat,* which will enter an identical price for the next unit. Once you are satisfied with your decision, you can send your limit prices to the market by clicking on *Validate*.



3.2 Finding how much you buy or sell

Whether you will buy or sell units and how much you buy or sell depends on how your limit price compares to others' limit prices, and how many units are in the economy.
After all players have entered all of their limit prices and validated them, the prices that all players have sent in are ranked together from the highest to the lowest. Those who enter the highest prices will possess the units in the economy after stage 1. For example, suppose that there are ten units in the economy. Those that send in the ten highest limit prices will then receive the ten units in the economy.

Often, the people who send in the highest limit prices will not be those who currently have the units. In that case, the people with the highest limit prices automatically purchase them from the people who currently have the units. Consider the following example. There are five players. Players 1, 2, and 3 each currently have one unit of K and players 4 and 5 do not have any units of K. Thus there are three units of K in the economy. Suppose that player 1 sends in a limit price of 500 for one unit of K. Player 2 sends in a limit price of 400 for one unit. Player 3 sends in a limit price of 600 for her first unit and 550 for her second unit. Player 4 sends in a bid of 630 for one unit. Player 5 sends in a limit price of 400 for one unit. In this example, player 3 receives two units and player 4 receives one unit of the total of three units of K that exist in the economy. This means that players 1 and 2 each sell one unit (they each had one before and will not have any after the market process) and players 3 and 4 each purchase one unit (player 3 had one already before the market process and player 4 did not have any).

As is clear from the above example, you are more likely to buy units for which the limit price is high and you are more likely to sell units for which the limit price is low compared to others' limit prices. Of course, at the time you choose your prices, you will not know what other players are doing. You must send in a number of limit prices that is at least as great as the number of units of K you currently have. To purchase units, you must send in more than that number.

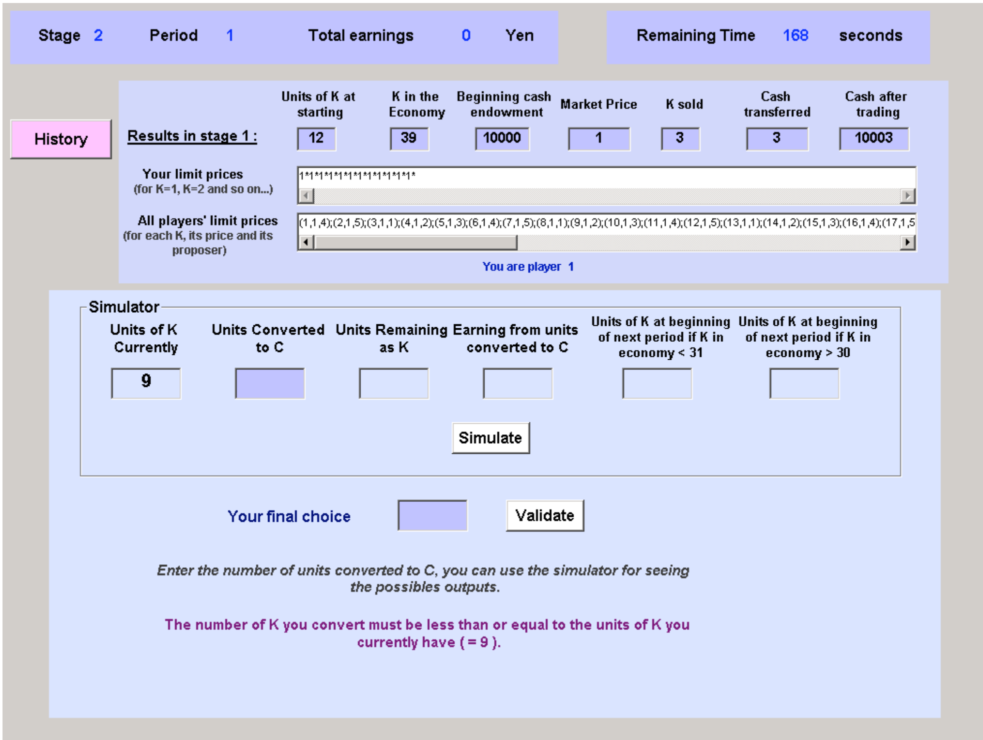
3.3 The price paid for purchases and sales

When you are required to sell a unit you receive some cash from the sale, increasing your earnings. Likewise, when you purchase units you are required to spend cash to obtain the units, decreasing your earnings. The price at which participants buy and sell their units, which we will refer to as the market price, is determined in the following manner.

When the limit prices are ranked from highest to lowest, we take the limit price that is ranked in the spot corresponding to the number of units of K in the economy. This price is called the market price. For example, for the limit prices described in the last subsection and three units in the economy, the third highest limit price submitted overall, the 550 player 3 sent in, becomes the market price. The market price is a per-unit price, so that if for example an individual buys five units, she pays five times the market price.

4. Consuming Units of K

In each period, after stage 1 is completed, all players enter stage 2. Below you will find a picture of the screen you see in Stage 2. At the top of the screen you will see the current *Period,* your *Total Earnings* in *Yen* for the experiment so far and the *Remaining Time* you have to complete this stage in *seconds*. The data from Stage 1 and the results from trading are also on this screen. On your screen, you will see *Units of K at starting*, which indicates the number of units you started the period with, the *Units of K in the Economy*, and your *Cash Endowment*. The screen also displays the *Market Price,* the price at which people bought and sold units in stage 1, *K bought/sold* on your part in stage 1, *Cash transferred* by you in stage 1 and *Cash after trading*, indicating how much cash you currently have.



Below these columns, you will see a row called *Your Limit Prices* summarizing the prices that you listed in Stage 1 for each unit; starting with the limit price you sent in for your first unit, followed by the limit price for the second, etc. A star separates these prices. The second row shows *All Player's Limit Prices.* These are the prices that everyone in the market listed in Stage 1 for each of their units. The numbers are read in the following way. The parentheses indicate (the rank of the limit price, the limit price entered, the player who submitted the unit). They are displayed in order from the highest limit price to the lowest.

In this Stage, you need to choose how many of the units of K you currently have that you want to consume. Consuming a unit increases your earnings but removes the K you consume from your inventory and from the economy. How consumption affects your earnings in Yen for the period can be determined using your **Redemption Value Sheet**, which you received at the beginning of the experiment.

4.1 Redemption Value Sheet and Consumption

The Redemption Value Sheet attached to these instructions shows the value in Yen from consuming units of K. The first column labeled *Units of K consumed* numbers the units from 1 through 28. The column labeled *Unit Value* indicates the additional amount of Yen you receive from consuming the unit indicated in the same row in the first column. The column *Total Value* shows the total amount of Yen you receive for consuming the quantity shown in the corresponding row in the first column. Notice that if more than 20 units of K are consumed, the value is the same as for 20 units, indicating that there is no additional value from consuming more than 20 units. The computer calculates your earnings in Yen automatically; you will see the number on the Stage 2 screen shown above once you validate your choice by clicking on *Validate*.

You can use the table entitled *Simulator* to help you make your decisions. On this table, you could see how your decision of how many units of K to consume will affect your earnings from consumption in Yen and the remaining K you have for next period. In the first field, you will find your *Units of K Currently*. In the second field, labeled *Units Converted to C* (C stands for consumption), you can type the number of units of K that you want to consume for the period. You must choose a number that is greater than or equal to 0 and less that or equal to number of units of K that you currently hold. After you make your decision, the remaining K will be recorded under *Units of Remaining K*. Under *Earnings from Units Converted to C* you will see the value in Yen resulting from your consumption of K. Finally, the Screen also shows the *Units of K remaining at the beginning of next period* if the economy wide K is less than 31 and if the economy wide K is greater than 30. The importance of the threshold level of K in the economy is explained in section 5. You can type different hypothetical amounts under *Units Converted to C* and click on *Simulate* to see how much K you would have next period and what your earnings would be if you chose that level of consumption. Once you make a final decision, type your decision where it says *Your Final Choice* and press *Validate*.

5. Production

The remaining K, that is, the amount of K that remains after you make your consumption decision, can be carried over to the next period. This K will be automatically converted to possibly more K. The amount that it is converted into is based on your **Production Schedule**. Thus, the amount of K you will have at the beginning of next period depends on the remaining K you have after consuming at the end of the current period and on your Production Schedule.

5.1 Production Schedule

The Production Schedule consists of two parts. When the total amount of K that the whole group has at the end of each period is less than or equal to 30, that is when the K in the Economy (that is the total Remaining K for all five people) is less than or equal to 30, use the left-hand-side of the Production Schedule to determine the amount of K that will be available to you at the beginning of next period. When the total remaining K in the economy exceeds 30, then you should use the right-hand-side of the schedule. In determining which side of the schedule is used, the total Remaining K is measured after consumption and before it grows at the beginning of the next period.

Under the column labeled *Remaining K* you will find the number of units of K you have remaining after your consumption decision. The number next to it in the column labeled *K at Market Open Next Period* is the amount of good K that will available to you at the beginning of next period. The calculation for determining how many units of K you have in the next period is done automatically by the computer.

6. Summary of Period Earnings

At the end of each period, the screen you see, entitled *Final Results for Period* will display a summary of the activity in the period. It will indicate your earnings in Yen for the period and your total earnings in the experiment thus far. Remember that earnings for the period in Yen are given by the cash endowment remaining after trading, minus your cash endowment at the beginning of the period, plus your earnings from consumption. That is:

> **Earnings for a period in Yen = cash endowment remaining after trading – cash endowment at the beginning of the period + period earnings from consumption**

7. Ending the Experiment

The period in which the experiment ends is determined in the following way. Before the experiment began, the experimenter rolled a 10-sided die a series of times to determine how long the experiment would continue. If the die came up with number 1 or 2 on the first roll, then the game will end after the first period and there are no more die rolls. Otherwise, if the die roll resulted in a number from 3 to 10, the experiment will go on to the next period, and the die is rolled again. If the die came up 1 or 2 on the second roll, the experiment will end after period 2. In other words, in any given period, there is a fixed 20 percent chance (the odds are 2 in 10) that the experiment ends right after the current period. There is always a 80 percent chance that there will be at least one more period after the current one.

However, the experiment will be restarted if it ends with more than half an hour remaining during the time for which you have been recruited. If it is restarted, you will again begin with the same number of units that you started with in period 1. On the other hand, if the experiment is still in progress at the end of the time for which you have been recruited, the experiment will be continued on another afternoon or evening. The experimenter will run another session, in which the beginning holding of K for each individual will be the same as the end of the current session. You are free to participate in the continuation of the session with the same ID number, picking up from where you left off today. If you choose not to continue on with the session at a later date, another participant will be recruited to take your place. The earnings of the participant filling your place will also be given to you for the remainder of the life of the current series of periods.

8. The History Screen

During stage 1 or stage 2, you can click on the button labeled *History* and you can access a history of your choices and of market activity for each past period. The information you can access includes the amount of K you held, the amount of K in the economy, your limit prices, the market price, the amount of K traded, the cash you have after trading, your earnings from consumption, the K remaining after your consumption, your period earnings, and your cumulative earnings.

>>>>>>>>>> Communication Treatment<<<<<<<<<<<<<<<

INSTRUCTIONS FOR EXPERIMENT

1. General Instructions

This is an experiment in the economics of decision-making. The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The amount of payment you receive depends partly on your decisions, partly on the decisions of others, and partly on chance. The currency used in the market is Yen. All trading will be in terms of the Yen. The cash payment to you at the end of the experiment will be in US dollars. The conversion rate is _____ Yen to 1 US dollar.

Once the experiment has started, no one is allowed to talk to anybody other than the experimenter. Anyone who violates this rule will lose his or her right to participate in this experiment. In addition to your earnings from the activity in the experiment, you will receive a …… payment for your participation.

2. Basic Concepts

The experiment will consist of a sequence of periods. At the beginning of each period, you will begin with a Cash Endowment of ______ Yen. You will also be given _____ units of a good called K on a one-time basis at the beginning of the first period of the experiment.

In each period, there will be an open **market**. You will use this market to buy and sell units of K. Buying units of K reduces your cash by the amount of Yen that you pay for your purchases, whereas selling increases the cash you have by the amount that you receive for your sales. Thus, selling and buying K determines in part the earnings you make in each period.

In addition, you will have a chance to choose how many units of K to **consume**. How much of K you consume during a period will also in part determine your earnings for the period. The K you do not consume can grow and can be sold or consumed in future periods.

Your **earnings** in a period are equal to **the amount of cash you have after buying and/or selling K minus the cash you began the period with, plus the earnings you receive from the consumption of K**. A detailed explanation of how to buy, sell and consume units of K is given later on in these instructions.

Each period is divided into stages. In stage 1, you can buy and sell units of K. In stage 2, you decide how much to consume. In stage 3, the K you have is converted to a different quantity of K that you begin the next period with.

3. Stage 1: Buying and Selling Units of K

The picture shown below is a copy of the first screen that you will see during Stage 1 of each period of the experiment. At the top of the screen you can find the *Period* number, the *Total Earnings* you have in *Yen* and the *Remaining Time* in *seconds* that you have to complete Stage 1. Below this information, you will find the number of *Units of K You Hold*, indicating the number of K that you currently have. You will also find the *Units of K in the Economy*, which is the total K that all five players currently have. You will also see the *Cash Endowment* for the period, indicating how much cash you currently have available for transactions.

3.1 Sending in Limit Prices to the Market

You will use this screen to indicate the number of units of K you want to trade. You do so using the spaces *Units of K* and *Limit Price*. Under *Units of K*, you must enter a series of numbers in an increasing manner. The numbers will appear in the large window on the left portion of the screen. Type in a 1 for the first row, a 2 for the second row, a 3 for third row, etc… Enter as many numbers as the most units of K that you are willing to hold. The minimum quantity of units you can list is equal to the number of K you currently hold, the maximum quantity of units you can list is equal to the number of units in the economy.

In the *Limit Price* field you must enter a **limit price** for each unit you list. The role of limit prices will be explained shortly. Each unit number must be accompanied by a limit price for the unit. The limit price will also appear in the large window on the left portion of the screen. Enter the limit price next to its corresponding unit. For example, if you enter 500 next to unit 1, it means that your limit price for the first unit is 500. If you enter a limit price of 450 next to the 2^{nd} unit, it means that your limit price for the second unit is 450, and so on.

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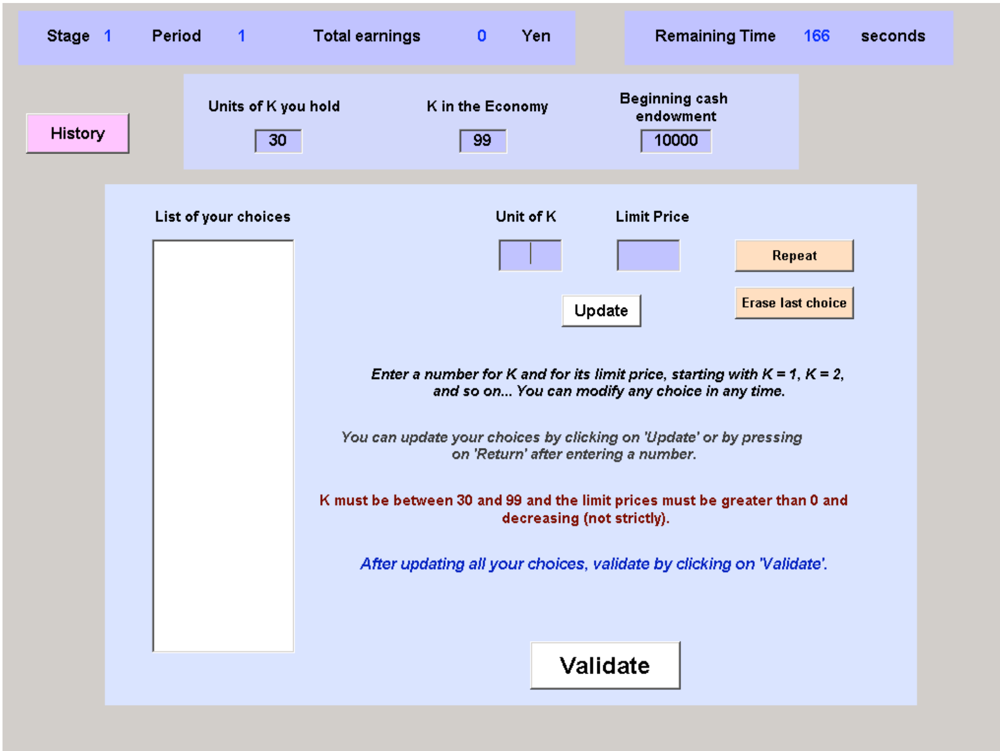

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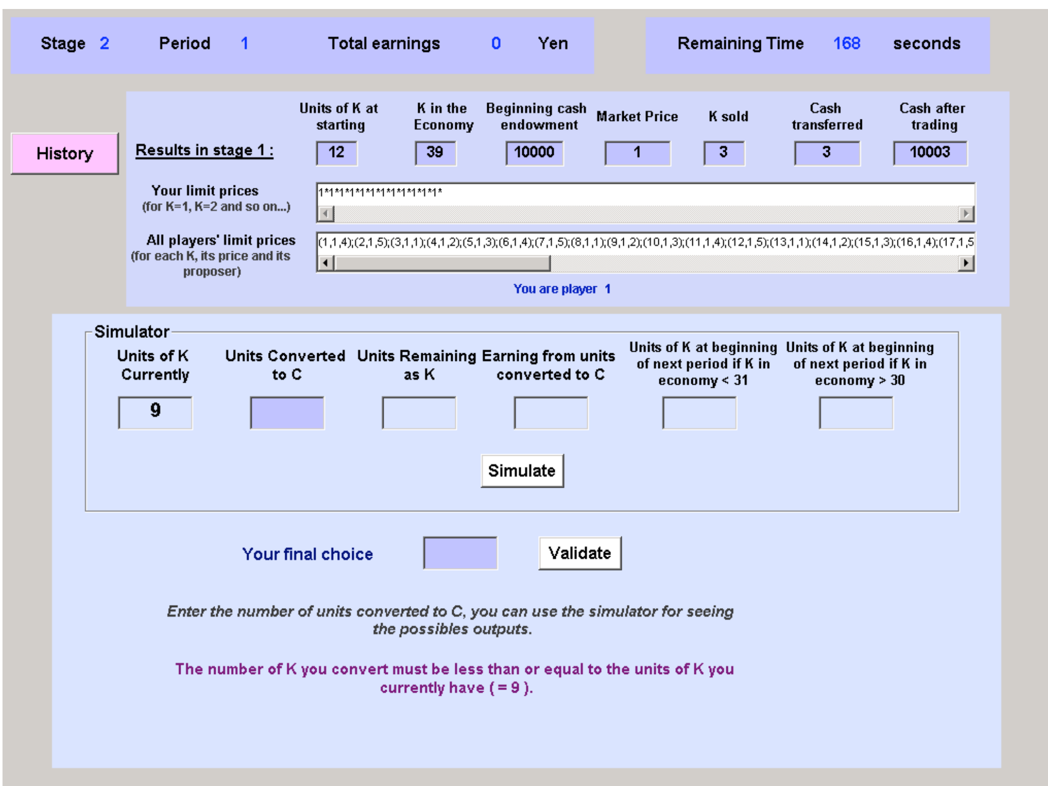

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In this Stage, you need to choose how many of the units of K you currently have that you want to consume. Consuming a unit increases your earnings but removes the K you consume from your inventory and from the economy. How consumption affects your earnings in Yen for the period can be determined using your **Redemption Value Sheet**, which you received at the beginning of the experiment.

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The Redemption Value Sheet attached to these instructions shows the value in Yen from consuming units of K. The first column labeled *Units of K consumed* numbers the units from 1 through 28. The column labeled *Unit Value* indicates the additional amount of Yen you receive from consuming the unit indicated in the same row in the first column. The column *Total Value* shows the total amount of Yen you receive for consuming the quantity shown in the corresponding row in the first column. Notice that if more than 20 units of K are consumed, the value is the same as for 20 units, indicating that there is no additional value from consuming more than 20 units. The computer calculates your earnings in Yen automatically; you will see the number on the Stage 2 screen shown above once you validate your choice by clicking on *Validate*.

You can use the table entitled *Simulator* to help you make your decisions. On this table, you could see how your decision of how many units of K to consume will affect your earnings from consumption in Yen and the remaining K you have for next period. In the first field, you will find your *Units of K Currently*. In the second field, labeled *Units Converted to C* (C stands for consumption), you can type the number of units of K that you want to consume for the period. You must choose a number that is greater than or equal to 0 and less that or equal to number of units of K that you currently hold. After you make your decision, the remaining K will be recorded under *Units of Remaining K*. Under *Earnings from Units Converted to C* you will see the value in Yen resulting from your consumption of K. Finally, the Screen also shows the *Units of K remaining at the beginning of next period* if the economy wide K is less than 31 and if the economy wide K is greater than 30. The importance of the threshold level of K in the economy is explained in section 5. You can type different hypothetical amounts under *Units Converted to C* and click on *Simulate* to see how much K you would have next period and what your earnings would be if you chose that level of consumption. Once you make a final decision, type your decision where it says *Your Final Choice* and press *Validate*.

5. Production

The remaining K, that is, the amount of K that remains after you make your consumption decision, can be carried over to the next period. This K will be automatically converted to possibly more K. The amount that it is converted into is based on your **Production Schedule**. Thus, the amount of K you will have at the beginning of next period depends on the remaining K you have after consuming at the end of the current period and on your Production Schedule.

5.1 Production Schedule

The Production Schedule consists of two parts. When the total amount of K that the whole group has at the end of each period is less than or equal to 30, that is when the K in the Economy (that is the total Remaining K for all five people) is less than or equal to 30, use the left-hand-side of the Production Schedule to determine the amount of K that will be available to you at the beginning of next period. When the total remaining K in the economy exceeds 30, then you should use the right-hand-side of the schedule. In determining which side of the schedule is used, the total Remaining K is measured after consumption and before it grows at the beginning of the next period.

Under the column labeled *Remaining K* you will find the number of units of K you have remaining after your consumption decision. The number next to it in the column labeled *K at Market Open Next Period* is the amount of good K that will available to you at the beginning of next period. The calculation for determining how many units of K you have in the next period is done automatically by the computer.

6. Summary of Period Earnings

At the end of each period, the screen you see, entitled *Final Results for Period* will display a summary of the activity in the period. It will indicate your earnings in Yen for the period and your total earnings in the experiment thus far. Remember that earnings for the period in Yen are given by the cash endowment remaining after trading, minus your cash endowment at the beginning of the period, plus your earnings from consumption. That is:

> **Earnings for a period in Yen = cash endowment remaining after trading – cash endowment at the beginning of the period + period earnings from consumption**

7. Ending the Experiment

The period in which the experiment ends is determined in the following way. Before the experiment began, the experimenter rolled a 10-sided die a series of times to determine how long the experiment would continue. If the die came up with number 1 or 2 on the first roll, then the game will end after the first period and there are no more die rolls. Otherwise, if the die roll resulted in a number from 3 to 10, the experiment will go on to the next period, and the die is rolled again. If the die came up 1 or 2 on the second roll, the experiment will end after period 2. In other words, in any given period, there is a fixed 20 percent chance (the odds are 2 in 10) that the experiment ends right after the current period. There is always a 80 percent chance that there will be at least one more period after the current one.

However, the experiment will be restarted if it ends with more than half an hour remaining during the time for which you have been recruited. If it is restarted, you will again begin with the same number of units that you started with in period 1. On the other hand, if the experiment is still in progress at the end of the time for which you have been recruited, the experiment will be continued on another afternoon or evening. The experimenter will run another session, in which the beginning holding of K for each individual will be the same as the end of the current session. You are free to participate in the continuation of the session with the same ID number, picking up from where you left off today. If you choose not to continue on with the session at a later date, another participant will be recruited to take your place. The earnings of the participant filling your place will also be given to you for the remainder of the life of the current series of periods.

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During stage 1 or stage 2, you can click on the button labeled *History* and you can access a history of your choices and of market activity for each past period. The information you can access includes the amount of K you held, the amount of K in the economy, your limit prices, the market price, the amount of K traded, the cash you have after trading, your earnings from consumption, the K remaining after your consumption, your period earnings, and your cumulative earnings

9. Communication with Other Subjects

Before stage one, you will have an opportunity to communicate with other participants. You will see a screen in which there will be a field entitled *Your Message*. You are free to type in any messages you would like concerning the experiment, and all other subjects will be able to read them on their screens. They can also type in messages that you will be able to read.

>>>>>>>>>>>>>>>> Voting Treatment <<<<<<<<<<<<<<

INSTRUCTIONS FOR EXPERIMENT

1. General Instructions

This is an experiment in the economics of decision-making. The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The amount of payment you receive depends partly on your decisions, partly on the decisions of others, and partly on chance. The currency used in the market is Yen. All trading will be in terms of the Yen. The cash payment to you at the end of the experiment will be in US dollars. The conversion rate is _____ Yen to 1 US dollar.

Once the experiment has started, no one is allowed to talk to anybody other than the experimenter. Anyone who violates this rule will lose his or her right to participate in this experiment. In addition to your earnings from the activity in the experiment, you will receive a …… payment for your participation.

2. Basic Concepts

The experiment will consist of a sequence of periods. At the beginning of each period, you will begin with a Cash Endowment of ______ Yen. You will also be given _____ units of a good called K on a one-time basis at the beginning of the first period of the experiment.

In each period, there will be an open **market**. You will use this market to buy and sell units of K. Buying units of K reduces your cash by the amount of Yen that you pay for your purchases, whereas selling increases the cash you have by the amount that you receive for your sales. Thus, selling and buying K determines in part the earnings you make in each period.

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Your **earnings** in a period are equal to **the amount of cash you have after buying and/or selling K minus the cash you began the period with, plus the earnings you receive from the consumption of K**. A detailed explanation of how to buy, sell and consume units of K is given in section 3.

Each period is divided into stages. In stage 1, you can buy and sell units of K. In stage 2, you decide how much to consume. In stage 3, the K you have is converted to a different quantity of K that you begin the next period with.

3. Stage 1: Buying and Selling Units of K

The picture shown below is a copy of the first screen that you will see during Stage 1 of each period of the experiment. At the top of the screen you can find the *Period* number, the *Total Earnings* you have in *Yen* and the *Remaining Time* in *seconds* that you have to complete Stage 1. Below this information, you will find the number of *Units of K You Hold*, indicating the number of K that you currently have. You will also find the *Units of K in the Economy*, which is the total K that all five players currently have. You will also see the *Cash Endowment* for the period, indicating how much cash you currently have available for transactions.

3.1 Sending in Limit Prices to the Market

You will use this screen to indicate the number of units of K you want to trade. You do so using the spaces *Units of K* and *Limit Price*. Under *Units of K*, you must enter a series of numbers in an increasing manner. The numbers will appear in the large window on the left portion of the screen. Type in a 1 for the first row, a 2 for the second row, a 3 for third row, etc… Enter as many numbers as the most units of K that you are willing to hold. The minimum quantity of units you can list is equal to the number of K you currently hold, the maximum quantity of units you can list is equal to the number of units in the economy.

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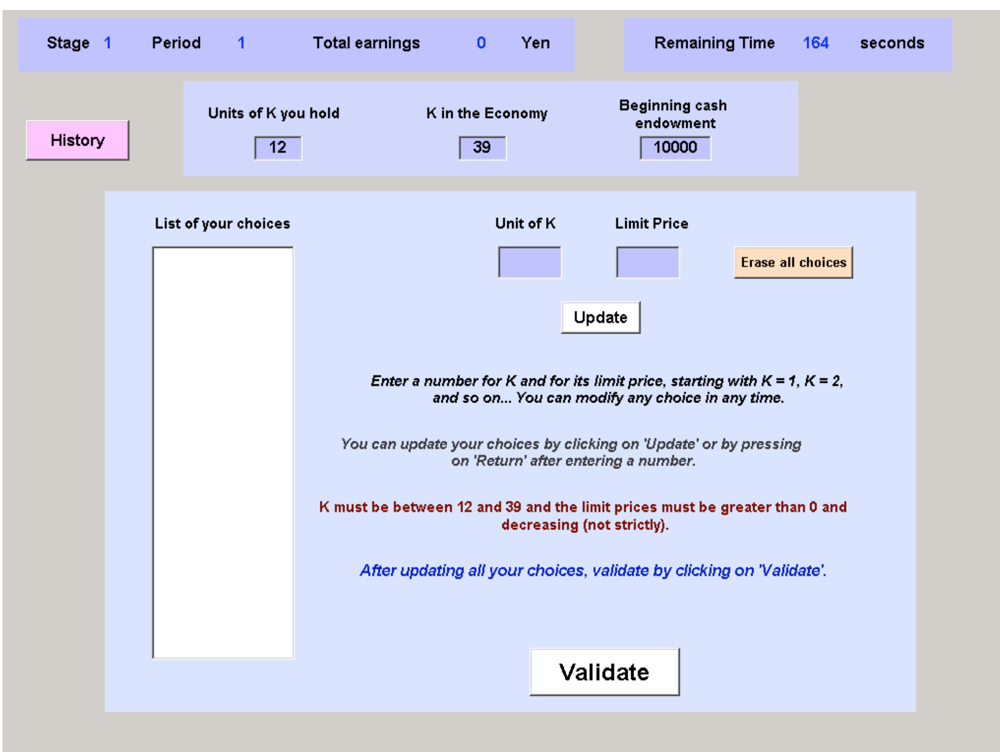

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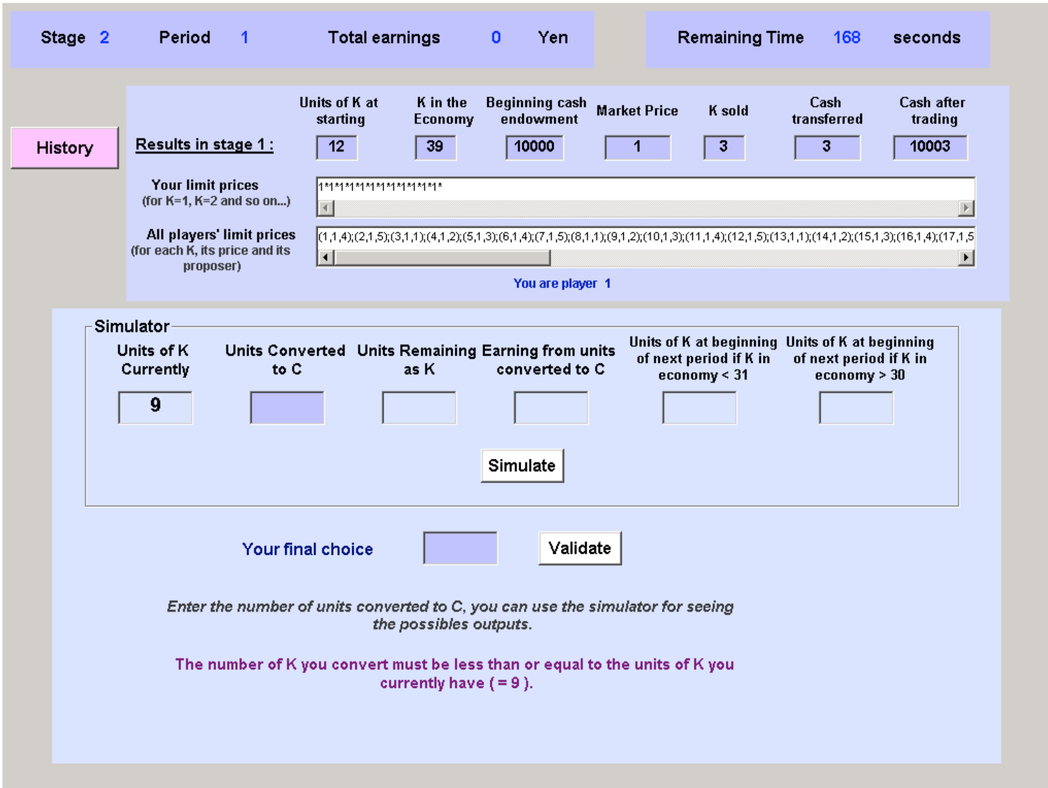
4. Consuming Units of K

In each period, after stage 1 is completed, all players enter stage 2. Below you will find a picture of the screen you see in Stage 2. At the top of the screen you will see the current *Period,* your *Total Earnings* in *Yen* for the experiment so far and the *Remaining Time* you have to complete this stage in *seconds*. The data from Stage 1 and the results from trading are also on this screen. On your screen, you will see *Units of K at Starting*, which indicates the number of units you started the period with, the *Units of K in the Economy*, and your *Cash Endowment*. The screen also displays the *Market Price,* the price at which people bought and sold units in stage 1, *K bought/sold* on your part in stage 1, *Cash transferred* by you in stage 1 and *Cash after trading*, indicating how much cash you currently have.



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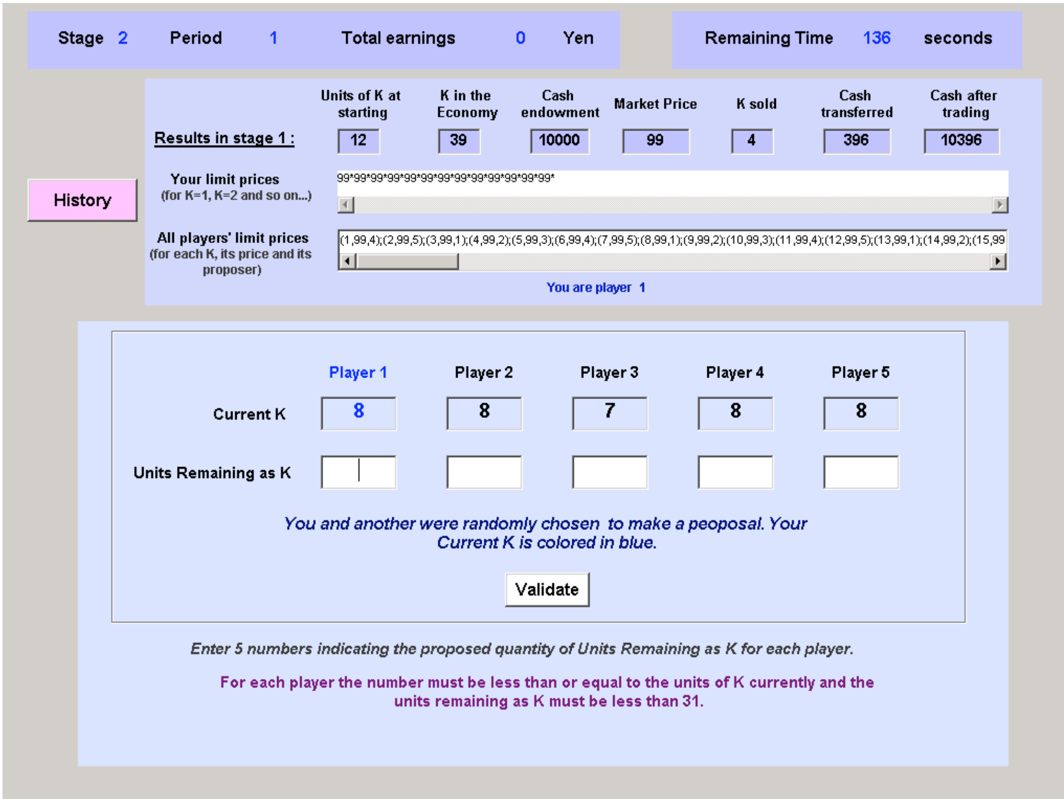
In this Stage, it will be decided how many of the units of K you currently have that you consume. Consuming a unit increases your earnings but removes the K you consume from your inventory and from the economy. How consumption affects your earnings in Yen for the period can be determined using your **Redemption Value Sheet**, which you received at the beginning of the experiment.

4.1 Redemption Value Sheet and Consumption

The Redemption Value Sheet attached to these instructions shows the value in Yen from consuming units of K. The first column labeled *Units of K consumed* numbers the units from 1 through 28. The column labeled *Unit Value* indicates the additional amount of Yen you receive from consuming the unit indicated in the same row in the first column. The column *Total* shows the total amount of Yen you receive for consuming the quantity shown in the corresponding row in the first column. Notice that if more than 20 units of K are consumed, the value is the same as for 20 units, indicating that there is no additional value from consuming more than 20 units.



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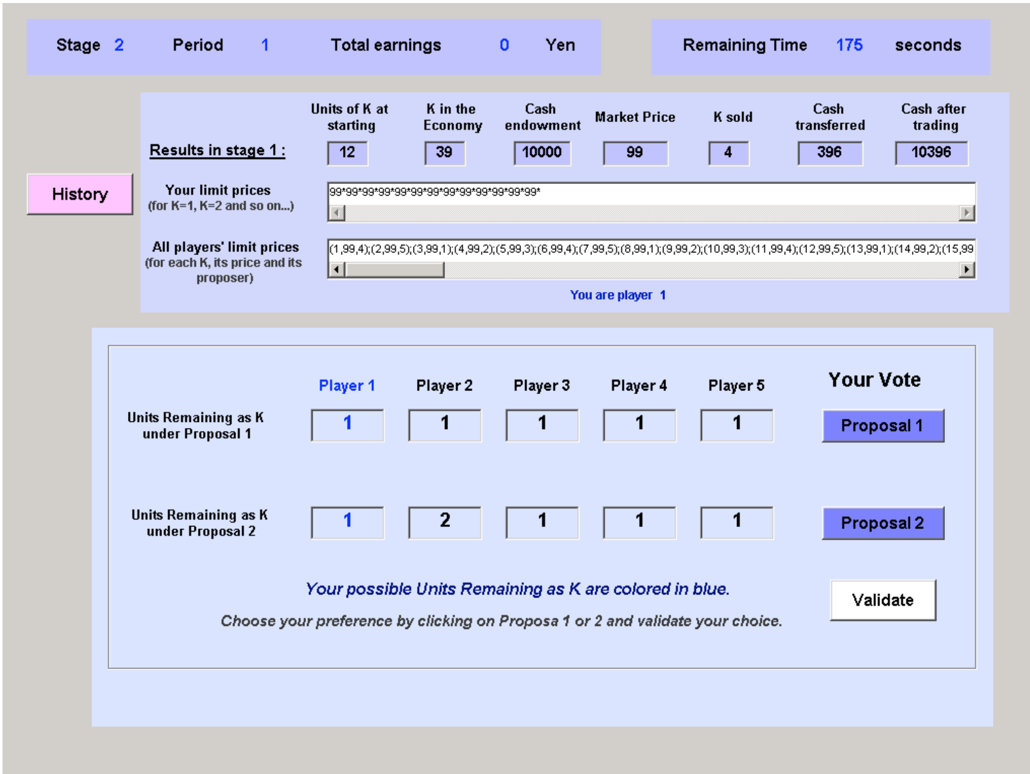
The two of you who have the screen displayed can propose an Amount Remaining as K to be held by each agent at the end of the period. In the top row, each player's current K is indicated. You can propose how much K will remain for each player at the end of the period by typing in numbers in the second row. For each player, you must enter a number between zero and their current K. The other person with the ability to submit a proposal may do the same. Whatever K is not remaining is consumed. For each person, the amount consumed is the difference between the Current K and the Units Remaining as K. For example, if player 1's current K is 7 units, and he has 3 units remaining, he consumes 4 units. Select the validate button to submit the proposal to a vote.

All five players will then see the following screen. The bottom half of the screen will display the two proposals. You can then vote for one of the proposals by the selecting the dark blue button on the right in the row corresponding to the proposal and selecting validate. The proposal that has a majority, three or more people, voting for it, is enacted. The program then indicates the final results for the period. Your consumption is indicated on the screen, as are your earnings from consumption (labeled earnings from units converted to C), which are calculated according to your Redemption Value Sheet.



5. Production

The remaining K, that is, the amount of K that remains after you make your consumption decision, can be carried over to the next period. This K will be automatically converted to possibly more K. The amount that it is converted into is based on your **Production Schedule**. Thus, the amount of K you will have at the beginning of next period depends on the remaining K you have after consuming at the end of the current period and on your Production Schedule.

5.1 Production Schedule

The Production Schedule consists of two parts. When the total amount of K that the whole group has at the end of each period is less than or equal to 30, that is when the K in the Economy (that is the total Remaining K for all five people) is less than or equal to 30, use the left-hand-side of the Production Schedule to determine the amount of K that will be available to you at the beginning of next period. When the total remaining K in the economy exceeds 30, then you should use the right-hand-side of the schedule. In determining which side of the schedule is used, the total Remaining K is measured after consumption and before it grows at the beginning of the next period.

Under the column labeled *Remaining K* you will find the number of units of K you have remaining after your consumption decision. The number next to it in the column labeled *K at Market Open Next Period* is the amount of good K that will available to you at the beginning of next period. The calculation for determining how many units of K you have in the next period is done automatically by the computer.

6. Summary of Period Earnings

At the end of each period, the screen you see, entitled *Final Results for Period* will display a summary of the activity in the period. It will indicate your earnings in Yen for the period and your total earnings in the experiment thus far. Remember that earnings for the period in Yen are given by the cash endowment remaining after trading, minus your cash endowment at the beginning of the period, plus your earnings from consumption.

> **Earnings for a period in Yen = cash endowment remaining after trading – cash endowment at the beginning of the period + period earnings from consumption**

7. Ending the Experiment

The period in which the experiment ends is determined in the following way. Before the experiment began, the experimenter rolled a 10-sided die a series of times to determine how long the experiment would continue. If the die came up with number 1 or 2 on the first roll, then the game will end after the first period and there are no more die rolls. Otherwise, if the die roll resulted in a number from 3 to 10, the experiment will go on to the next period, and the die is rolled again. If the die came up 1 or 2 on the second roll, the experiment will end after period 2. In other words, in any given period, there is a fixed 20 percent chance (the odds are 2 in 10) that the experiment ends right after the current period. There is always a 80 percent chance that there will be at least one more period after the current one.

However, the experiment will be restarted if it ends with more than half an hour remaining during the time for which you have been recruited. If it is restarted, you will again begin with the same number of units that you started with in period 1. On the other hand, if the experiment is still in progress at the end of the time for which you have been recruited, the experiment will be continued on another afternoon or evening. The experimenter will run another session, in which the beginning holding of K for each individual will be the same as the end of the current session. You are free to participate in the continuation of the session with the same ID number, picking up from where you left off today. If you choose not to continue on with the session at a later date, another participant will be recruited to take your place. The earnings of the participant filling your place will also be given to you for the remainder of the life of the current series of periods.

8. The History Screen

During stage 1 or stage 2, you can click on the button labeled *History* and you can access a history of your choices and of market activity for each past period. The information you can access includes the amount of K you held, the amount of K in the economy, your limit prices, the market price, the amount of K traded, the cash you have after trading, your earnings from consumption, the K remaining after your consumption, your period earnings, and your cumulative earnings.

>>>>>>>>>>>>>> Hybrid Treatment <<<<<<<<<<<<<<<<<

INSTRUCTIONS FOR EXPERIMENT

1. General Instructions

This is an experiment in the economics of decision-making. The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The amount of payment you receive depends partly on your decisions, partly on the decisions of others, and partly on chance. The currency used in the market is Yen. All trading will be in terms of the Yen. The cash payment to you at the end of the experiment will be in US dollars. The conversion rate is _____ Yen to 1 US dollar.

Once the experiment has started, no one is allowed to talk to anybody other than the experimenter. Anyone who violates this rule will lose his or her right to participate in this experiment. In addition to your earnings from the activity in the experiment, you will receive a …… payment for your participation.

2. Basic Concepts

The experiment will consist of a sequence of periods. At the beginning of each period, you will begin with a Cash Endowment of ______ Yen. You will also be given _____ units of a good called K on a one-time basis at the beginning of the first period of the experiment.

In each period, there will be an open **market**. You will use this market to buy and sell units of K. Buying units of K reduces your cash by the amount of Yen that you pay for your purchases, whereas selling increases the cash you have by the amount that you receive for your sales. Thus, selling and buying K determines in part the earnings you make in each period.

In addition, you will have a chance to choose how many units of K to **consume**. How much of K you consume during a period will also in part determine your earnings for the period. The K you do not consume can grow and can be sold or consumed in future periods.

Your **earnings** in a period are equal to **the amount of cash you have after buying and/or selling K minus the cash you began the period with, plus the earnings you receive from the consumption of K**. A detailed explanation of how to buy, sell and consume units of K is given in section 3.

Each period is divided into stages. In stage 1, you can buy and sell units of K. In stage 2, you decide how much to consume. In stage 3, the K you have is converted to a different quantity of K that you begin the next period with.

3. Stage 1: Buying and Selling Units of K

The picture shown below is a copy of the first screen that you will see during Stage 1 of each period of the experiment. At the top of the screen you can find the *Period* number, the *Total Earnings* you have in *Yen* and the *Remaining Time* in *seconds* that you have to complete Stage 1. Below this information, you will find the number of *Units of K You Hold*, indicating the number of K that you currently have. You will also find the *Units of K in the Economy*, which is the total K that all five players currently have. You will also see the *Cash Endowment* for the period, indicating how much cash you currently have available for transactions.

3.1 Sending in Limit Prices to the Market

You will use this screen to indicate the number of units of K you want to trade. You do so using the spaces *Units of K* and *Limit Price*. Under *Units of K*, you must enter a series of numbers in an increasing manner. The numbers will appear in the large window on the left portion of the screen. Type in a 1 for the first row, a 2 for the second row, a 3 for third row, etc… Enter as many numbers as the most units of K that you are willing to hold. The minimum quantity of units you can list is equal to the number of K you currently hold, the maximum quantity of units you can list is equal to the number of units in the economy.

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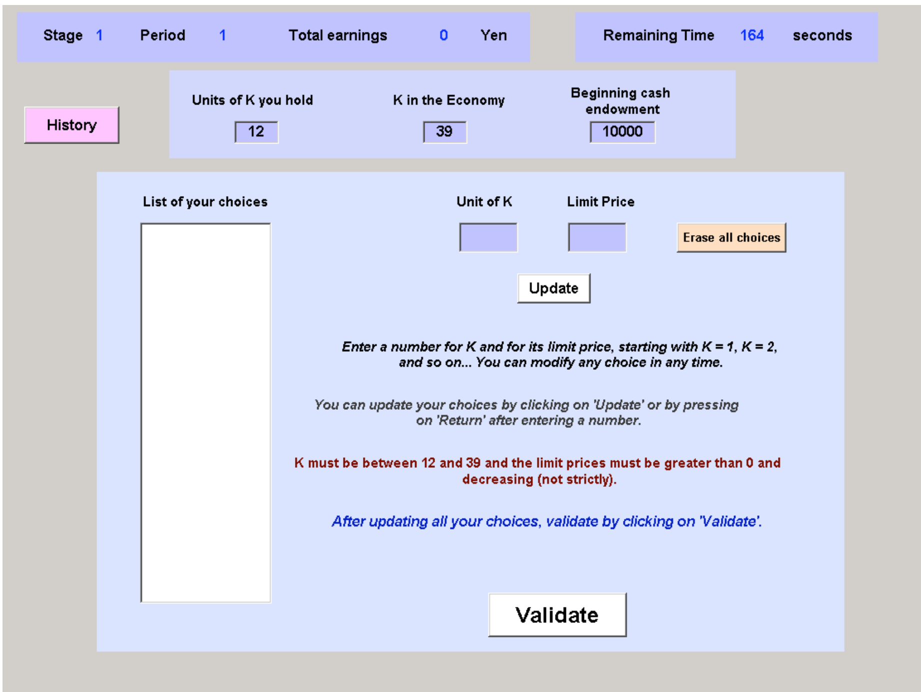

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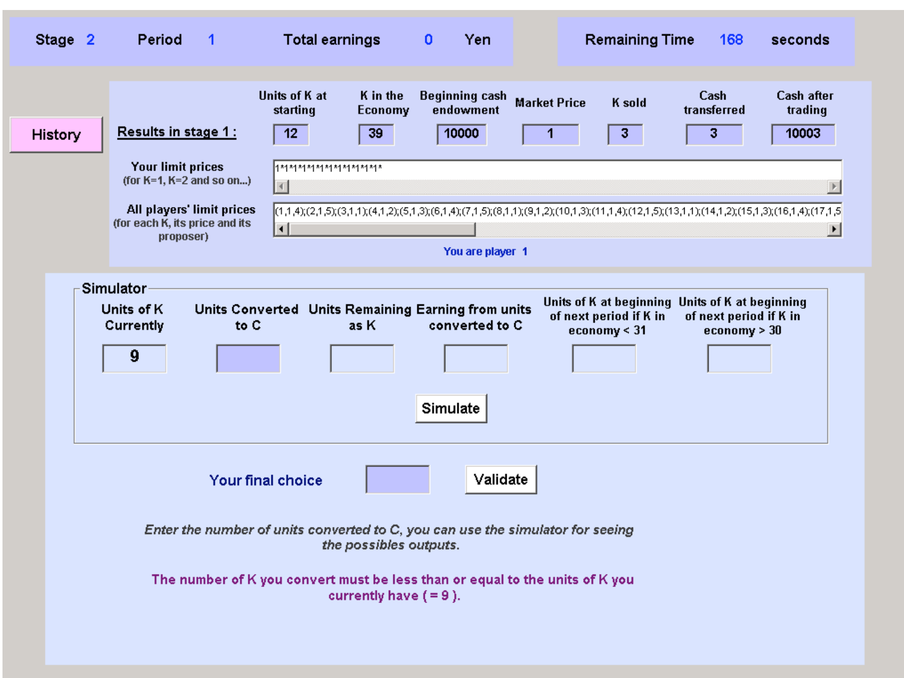
4. Consuming Units of K

In each period, after stage 1 is completed, all players enter stage 2. Below you will find a picture of the screen you see in Stage 2. At the top of the screen you will see the current *Period,* your *Total Earnings* in *Yen* for the experiment so far and the *Remaining Time* you have to complete this stage in *seconds*. The data from Stage 1 and the results from trading are also on this screen. On your screen, you will see *Units of K at Starting*, which indicates the number of units you started the period with, the *Units of K in the Economy*, and your *Cash Endowment*. The screen also displays the *Market Price,* the price at which people bought and sold units in stage 1, *K bought/sold* on your part in stage 1, *Cash transferred* by you in stage 1 and *Cash after trading*, indicating how much cash you currently have.



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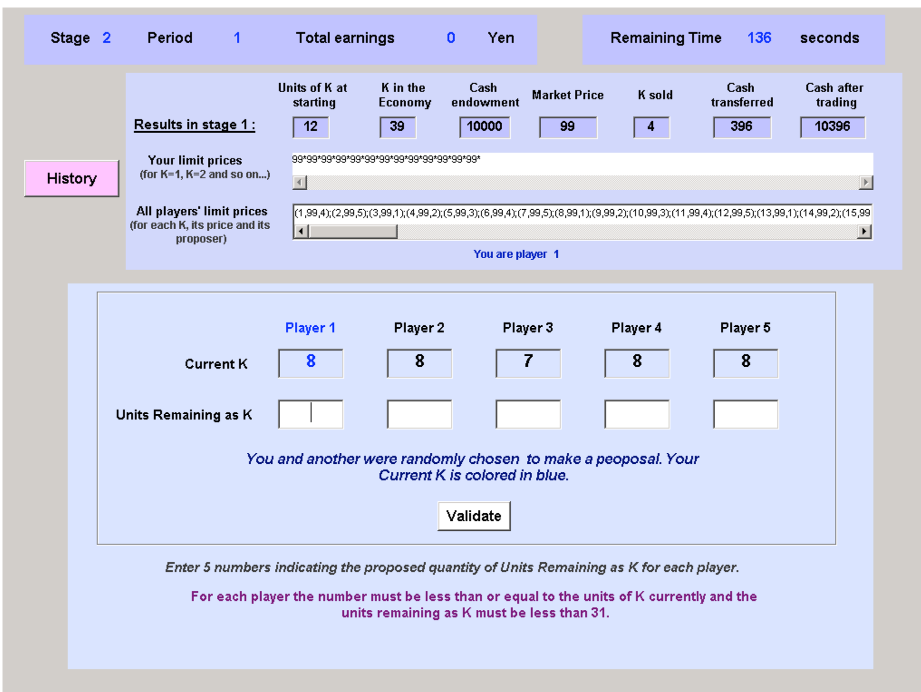

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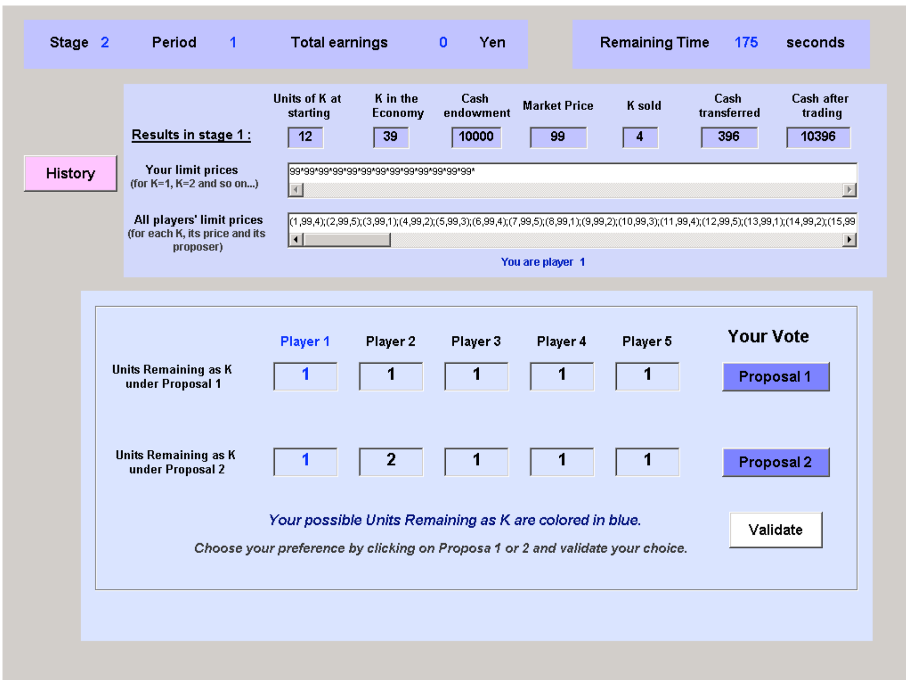

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The Production Schedule consists of two parts. When the total amount of K that the whole group has at the end of each period is less than or equal to 30, that is when the K in the Economy (that is the total Remaining K for all five people) is less than or equal to 30, use the left-hand-side of the Production Schedule to determine the amount of K that will be available to you at the beginning of next period. When the total remaining K in the economy exceeds 30, then you should use the right-hand-side of the schedule. In determining which side of the schedule is used, the total Remaining K is measured after consumption and before it grows at the beginning of the next period.

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At the end of each period, the screen you see, entitled *Final Results for Period* will display a summary of the activity in the period. It will indicate your earnings in Yen for the period and your total earnings in the experiment thus far. Remember that earnings for the period in Yen are given by the cash endowment remaining after trading, minus your cash endowment at the beginning of the period, plus your earnings from consumption.

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The period in which the experiment ends is determined in the following way. Before the experiment began, the experimenter rolled a 10-sided die a series of times to determine how long the experiment would continue. If the die came up with number 1 or 2 on the first roll, then the game will end after the first period and there are no more die rolls. Otherwise, if the die roll resulted in a number from 3 to 10, the experiment will go on to the next period, and the die is rolled again. If the die came up 1 or 2 on the second roll, the experiment will end after period 2. In other words, in any given period, there is a fixed 20 percent chance (the odds are 2 in 10) that the experiment ends right after the current period. There is always a 80 percent chance that there will be at least one more period after the current one.

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During stage 1 or stage 2, you can click on the button labeled *History* and you can access a history of your choices and of market activity for each past period. The information you can access includes the amount of K you held, the amount of K in the economy, your limit prices, the market price, the amount of K traded, the cash you have after trading, your earnings from consumption, the K remaining after your consumption, your period earnings, and your cumulative earnings

9. Communication with Other Subjects

Before stage one, you will have an opportunity to communicate with other participants. You will see a screen in which there will be a field entitled *Your Message*. You are free to type in any messages you would like concerning the experiment, and all other subjects will be able to read them on their screens. They can also type in messages that you will be able to read.