Laboratory Experiments with an Expectational Phillips Curve

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ABSTRACT

We pay human subjects to be the policy maker and the public in an expectational Phillips curve model. Policy makers often find ways to achieve the time-inconsistent optimal inflation rate, at least for a while. But backsliding toward the sub-optimal Nash (time consistent) inflation rate also occurs.

1. Introduction

This paper describes experiments with human subjects in an environment that provokes the time consistency problem of Kydland and Prescott (1977). There is an expectational Phillips curve, a single policy maker able to set inflation up to a random error term, and a public forecasting the inflation rate. The policy maker knows the model. Kydland and Prescott considered a one-period model. They described how inability to precommit to an inflation policy causes the policy maker to set inflation higher than if it can precommit. Kydland and Prescott considered a one-period model. Barro and Gordon (1982) found better reputational equilibria when the economy is repeated over time. With repetition, the availability of history-dependent strategies multiplies the range of equilibrium outcomes, some better than the one-period time-consistent one, others worse.

Commentators including Blinder (1998) and McCallum (1995) assert that in practice the time consistency problem can be solved through some unspecified process that, in the terminology of an American sports shoe advertisement, lets the monetary authority 'just do it'. Here 'it' is to choose the optimal or Ramsey target inflation rate. Although reputational macroeconomics provides no support for the 'just do it' phrase as a piece of policy *advice*,[1] the range of outcomes predicted by that theory is big enough to rationalize 'just do it' behavior. The large set of outcomes motivated us to put human subjects inside a Kydland-Prescott environment.

We paid undergraduate students to perform as policy makers and private forecasters in a repeated version of the Kydland-Prescott economy. A single policy maker repeatedly faces N forecasters whose average forecast of inflation positions an expectational Phillips curve.

Inspired by the theoretical literature, we ask the following questions: (1) *Emergence of Ramsey:* Is there a tendency for the optimal time-inconsistent (Ramsey) one-period outcome to emerge as time passes within an experiment? (2) *Backsliding:* After policy maker has nearly achieved Ramsey inflation, does inflation ever drift back toward

[1] The theory identifies multiple systems of expectations about its behavior that the policy maker will want to conform. It provides no guidance about how to switch from one system of expectations to another.

Nash inflation? (3) *Focal points:* Are there other 'focal points' besides the Nash and Ramsey inflation rates? (4) History-dependence: Is there evidence of 'carry over' across sessions in the private agents' forecasts of inflation? (5) *Inferior forecasting:* Are there sometimes systematic average errors in forecasting inflation? Our answers to all five questions are yes. The positive answer to question (1) provides support for the 'just do it' position, but qualified by the positive answer to question (2).

2. The environment

Our basic model is Kydland and Prescott's. Let $(U_t, y_t, x_t, \hat{x}_t)$ denote the unemployment rate, the inflation rate, the sytematic part of the inflation rate, and the public's expected rate of inflation, respectively. The policy maker sets x_t, the public sets $\hat{x}_t$, and the economy determines outcomes (y_t, U_t).

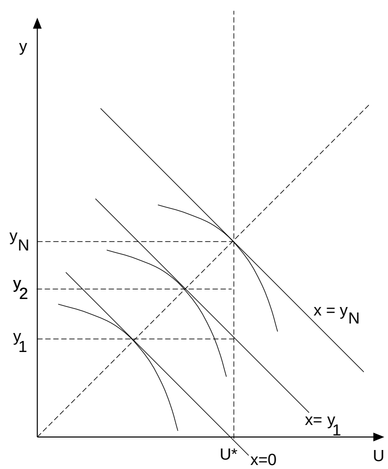

Figure 2.1: The Nash equilibrium and Ramsey outcome for the Kydland-Prescott model.

The data are generated by the natural unemployment rate model

$$U_t = U^* - \theta (y_t - \hat{x}_t) + v_{1t} \tag{2.1a}$$

$$y_t = x_t + v_{2t} \tag{2.1b}$$

$$x_t = \hat{x}_t, \tag{2.1c}$$

where $\theta > 0$, $U^* > 0$, and v_t is a (2×1) i. i. d. Gaussian random vector with $Ev_t = 0$, diagonal contemporaneous covariance matrix and $Ev_{jt}^2 = \sigma_{vj}^2$. Here U^* is the natural rate of unemployment and $-\theta$ is the slope of an expectations-augmented Phillps curve. According to $(2.1a)$, there is a family of Philips curves indexed by $\hat{x}_t$. Condition $(2.1b)$ states that the government sets inflation up to a random term v_{2t}. Condition $(2.1c)$ imposes rational expectations for the public. It embodies the idea that private agents face a raw forecasting problem: their payoffs vary inversely with their squared forecasting error. System (2.1) embodies the natural unemployment rate hypothesis: surprise inflation lowers the unemployment rate but anticipated inflation does not.

2.1. Nash and Ramsey equilibria and outcomes

The literature focuses on two equilibria of the one-period model. Both equilibria assume the government knows the correct model. Called the Nash and the Ramsey equilibria, they come from different timing protocols. The Ramsey outcome is better than the Nash outcome, symptomatic of a time inconsistency problem.

To define a Nash equilibrium, we need

Definition 2.1. A government *best response* map $x_t = B(\hat{x}_t)$ solves the problem

$$\min_{x_t} E\left(U_t^2 + y_t^2\right) \tag{2.2}$$

subject to $(2.1a)$, $(2.1b)$, taking $\hat{x}_t$ as given.

The best response map is $x_t = \frac{\theta}{\theta^2+1}U^* + \frac{\theta^2}{\theta^2+1}\hat{x}_t$. A Nash equilibrium incorporates a government best response and rational expectations for the public:

Definition 2.2. A *Nash equilibrium* is a pair $(x, \hat{x})$ satisfying (a) $x = B(\hat{x})$, and (b) $\hat{x} = x$. A *Nash outcome* is the associated (U_t, y_t).

Definition 2.3. The *Ramsey plan* x_t solves the problem of minimizing (2.2) subject to $(2.1a)$, $(2.1b)$, and $(2.1c)$. The *Ramsey outcome* is the associated (U_t, y_t).

A Ramsey outcome dominates a Nash outcome. The Ramsey plan is $\hat{x}_t = x_t = 0$ and the Ramsey outcome is $U_t = U^* - \theta v_{2t} + v_{1t}, y_t = v_{2t}$. The Nash equilibrium is $\hat{x}_t = x_t = \theta U^*$ and the Nash outcome is $U_t = U^* - \theta v_{2t} + v_{1t}, y_t = \theta U^* + v_{2t}$. The addition of constraint (2.1c) to the government's problem in the Ramsey plan makes the government achieve better outcomes by taking into account how its actions affect the public's expectations. The superiority of the Ramsey outcome reflects the value to the government of being able to commit to a policy before the public sets expectations.

3. Repetition

We design our experiments to implement an infintely repeated version of the Kydland-Prescott economy. The objective of the monetary authority is to maximize

$$J = -E_0 (1-\delta) \sum_{t=0}^{\infty} \delta^t \left(U_t^2 + y_t^2\right), \quad \delta \in (0,1). \tag{3.1}$$

The objective of private agents continues to be to minimize the one-step-ahead forecast error variance in forecasting inflation.

Three types of theories apply to this setting.

(i.) *Subgame perfection.* Reputational macroeconomics, also called the theory of credible or sustainable plans,[2] studies subgame perfect equilibria with history-dependent strategies. The theory discovers a set of equilibrium outcomes. For big enough discount factor δ, this set includes one that repeats the Ramsey outcome forever and others that sustain worse than the one-period Nash outcome. One sensible reaction is that because it contains so many possible equilibria, the theory says little empirically.

(ii.) *Adaptive expectations (1950's).* If the government believes that the public forms expectations by Cagan-Friedman adaptive expectations,[3] a version of Phelps's (1967) control problem implies that with a high enough discount factor, the government will eventually push inflation toward the Ramsey outcome. Cho and Matsui (1995) refined this idea in the context of a broad class of expectations formations mechanisms for the public that satisfy the same 'induction hypothesis' that adaptive expectations exhibits: if sustained long enough, a constant inflation rate will eventually come to be expected by the public.[4]

(iii.) *Adaptive expectations (1990's)* Sargent (1999) shows that a self-confirming equilibrium (see Fudenberg and Levine (1995)) of the Kydland-Prescott model yields the pessimistic Nash equilibrium outcome. Sims (1988), Sargent (1999), Cho and Sargent (1999), and Williams (1999) perturb the behavior rules of that self-confirming equilibrium by imputing to the policy maker doubts about model specification that cause him to use a constant-gain learning algorithm. Those papers show that the resulting model has both (1) 'mean dynamics' propelling it toward the self-confirming equilibrium, and (2) 'escape dynamics' expelling it toward the Ramsey outcome. Sample paths display recurrent abrupt stabilizations prompted by experimentation-induced discovery by the monetary authority of an approximate natural rate hypothesis government, followed by gradual backsliding toward the (inferior) self-confirming equilbrium.

2 See Stokey (1989) for a brief survey.

3 This form of adaptative expectations specifies $\hat{x}_t = (1-\lambda) \sum_{j=0}^{\infty} \lambda^j y_{t-j-1}$, where $\lambda \in (0,1)$.

4 Cho and Matsui (1999) study a version of the repeated model with alternating choices by the government and the public. They find that, depending on relative discount factors, the one period Nash outcome is excluded as an equilibrium outcome, and that a narrow range of outcomes near Ramsey can be expected under some parameter settings.

4. Experiments

4.1. Design

A group of $N+1$ students composes the economy; we set N equal to $3, 4$ or 5. The first N students form the public. Their decision is to forecast the inflation rate for each period of the experiment; $\hat{x}_t$ is determined as the average of the citizens' forecasts. Citizens receive payoffs that rise as their session-average squared forecast errors fall. Student $N+1$, chosen at random, is the policy maker. Each period, student $N+1$ sets a target inflation rate, x_t. A random number generator sets v_{2t} and the actual inflation rate equals $y_t = x_t + v_{2t}$. Unemployment is then generated by the Phillips curve (2.1a). Student $N+1$'s payoff varies inversely with the session-wide average of $U_t^2 + y_t^2$. The same student remains the policy maker throughout all sessions within a single experiment. Sessions within an experiment are separated by a stopping time (see below).

4.2. Knowledge

The policy maker knows:

- The true Phillips curve (2.1).

- The existence of private agents who are trying to forecast its action.

- The histories of outcomes in the current experiment up to the current time.

The private forecasters know:

- The history of inflation, including prior sessions of the current experiment. At the beginning of an economy, there is no history. The private forecasters do not know the structure of the economy. They know that a policy maker sets inflation up to a random term.

4.3. Physical details

Subjects sit at computer terminals and are isolated from one another. They receive written instructions at the beginning of each experiment. Appendices A and B reproduce the instructions. All experiments were conducted at the Micro computer lab of the Simon Fraser University, Burnaby, Canada. Subjects were SFU undergraduate economics majors.

4.4. Stopping rule

We followed Duffy and Ochs (1998) and Marimon, McGrattan, and Sargent (1989) in using a random stopping rule to implement an infinite horizon and to discount future payoffs. At the end of an experimental session, the computer drew a random number from a uniform distribution over $[0,1]$. If this random number was less than 0.98, the experimental session would continue for one more period. If the number was greater than 0.98, the session was terminated. An upper bound on the duration of an individual session was set at 100 time periods.

The parameter values used in the experiments were: $U^* = 5, \theta = 1$, and discount parameter $\delta = 0.98$. Two sets of values of σ were used, $\sigma \equiv \sigma_1 = \sigma_2 = 0.3$ and $\sigma \equiv \sigma_1 = \sigma_2 = 0.03$. In addition to the setting of σ, an information variable (yes or no) records whether the policy maker was told the value of $\hat{x}_t$ from the previous period.

We label an 'economy' a set of experiments with the same policy maker and group of forecasters. Each economy has several sessions.

We conducted experiments at two times. In April 1998 we created experiments with 3 economies. Between February and April 1999 we created 9 more economies. Table 4.1 summarizes the treatment variables across economies economies.[5]

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[5] We used two alternative scales for the payoffs for the forecasters. For economies 1-8, we used $-.5(y_t - \hat{x}_{it})^2$, while for economies 9-12 we used $-5(y_t - x_{it})^2$. Say more about why.

Table 4.1: Design of Experiments

experiment	sessions	information	σ	N
1	3	*	.03	4
2	2	**	.03	4
3	3	***	.3	5
4	2	yes	.3	3
5	2	yes	.3	4
6	9	yes	.3	3
7	6	yes	.3	4
8	9	yes	.3	4
9	4	yes	.3	4
10	2	yes	.3	4
11	9	yes	.3	4
12	9	yes	.3.	4

5. Outcomes

Table 5.1 and Fig. C.1 – Fig. C.12 describe the outcomes.[6] Each economy corresponds to one set of $N+1$ students. An economy contains several sessions, determined by the realization of a random variable that terminated the session. The various panels in Fig. C.1–Fig. C.12 correspond to different sessions within the same group of students.

The columns of Table 5.1 report the means and standard deviations of $x_t, \hat{x}_t, y_t, U_t, -.5(U_t^2 + y_t^2)$ across all sessions for each group. For the parameter values $U^* = 5, \theta = 1$, the population values for these variables at the Nash equilibrium are $5, 5, 5, 5, -25$. For the Ramsey outcome, the values are $0, 0, 0, 5, -12.5$.

[6] In Table 5.1, (*) denotes (no, yes, yes), (**) denotes (no, yes), and (***) denotes (no, yes, yes) in successive sessions.

Table 5.1: Means and standard deviations of outcomes.

Economy	x	$\hat{x}$	y	U	gov. payoff
Nash	5	5	5	5	-25
Ramsey	0	0	0	5	-12.5
1	4.1075	4.1589	4.1040	4.9301	-22.3235
	(1.5270)	(1.4914)	(1.5299)	(1.6823)	(5.5358)
2	1.4937	1.5047	1.4888	5.0183	-16.5486
	(2.2521)	(2.2286)	(2.2522)	(0.8135)	(7.2296)
3	1.1266	1.1455	1.1162	5.0263	-14.0370
	(1.1115)	(1.0726)	(1.1347)	(0.5334)	(3.1575)
4	1.3326	1.4218	1.2930	5.1438	-14.5550
	(0.7794)	(0.8094)	(0.8360)	(0.5383)	(2.8898)
5	2.0143	2.2536	1.9998	5.2495	-18.0040
	(1.7884)	(1.7682)	(1.8025)	(1.1115)	(7.5711)
6	1.7888	1.9327	1.8181	4.4238	-20.3153
	(3.6877)	(3.1646)	(3.5831)	(4.0828)	(27.1544)
7	1.3561	1.4444	1.3080	5.0956	-14.7334
	(1.1482)	(1.1892)	(1.1962)	(0.6071)	(3.8102)
8	0.7879	0.8354	0.7582	5.0545	-13.5492
	(0.7897)	(0.9031)	(0.8551)	(0.4979)	(3.0613)
9	5.8802	5.8129	5.8274	4.9490	-31.8680
	(1.9699)	(1.7939)	(1.9725)	(1.1919)	(8.7549)
10	2.4640	2.5443	2.4158	5.1006	-20.8438
	(2.4087)	(2.0490)	(2.4543)	(1.9718)	(11.6304)
11	3.6396	3.6664	3.6158	5.0216	-19.7498
	(0.7379)	(0.7217)	(0.7873)	(0.7706)	(4.6579)
12	2.6957	2.7048	2.6659	5.0161	-18.8765
	(1.7212)	(1.1878)	(1.7263)	(1.5879)	(15.8123)

5.1. Patterns

Table 5.2 summarizes what we see to be the patterns in Fig. C.1–Fig. C.12. The column labels mean the following. ‘Ramsey’ indicates

Table 5.2: Patterns of results

Economy	Ramsey	back-sliding	other focal	systematic errors	experi-mentation	rank
1	x					11
2	x					5
3	x	x				2
4	x					3
5	x	x			x	6
6	x	x	y		x	9
7	x					4
8	x					1
9			y			12
10	x	x			x	10
11			x	x		8
12			x	x		7

that the policy maker pushes the system to Ramsey at least for a substantial length of time (e.g., see Fig. C.1 and Fig. C.2 for economies 1 and 2). ‘Backsliding’ indicates a resurgence of inflation after having attained Ramsey (e.g., see Fig. C.3 and Fig. C.6). ‘Other focal’ indicates sustained inflation at values distinct from the Ramsey or Nash inflation (e.g., see Fig. C.9). ‘Systematic errors’ denotes substantial runs where $\hat{x}_t$ deviates from x_t (e.g., see Fig. C.11 and Fig. C.12). ‘Experimentation’ indicates the presence of episodes in which the monetary authority seems to be engaging in purposeful experimentation. ‘Rank’ denotes the rank order of the experiments in terms of the economy-wide average payoff for the monetary authority. An ‘x’ signifies strong evidence for the pattern in question, a ‘y’ weaker evidence.

We interpret the results as follows.

- ♡ In nine of the twelve experiments, the policy maker pushes inflation to near the Ramsey value for many periods.
- ♡ Backsliding occurs in four of twelve economies.
- ♡ Experimentation occurs in two of twelve economies.
- ♡ Economy 9 has a bad or indifferent policy maker.
- ♡ Systematic average forecast errors occur only in two experiments, and then only in the first session of each.

- ♡ Most of the transitions from Nash to Ramsey are smooth. Few if any have the drama of the Volcker-like rapid disinflations produced by the escape route dynamics of Cho and Sargent (1999), Sargent (1999), and Williams (1999). Depending on parameter values, they may resemble the pattern predicted by Phelps (1967) and Cho and Matsui (1995).

5.2. Things to do

1. Study the distribution of $\hat{x}_{it}$ at the beginning of sessions.
    1.1. For the first period of each session within an economy, study the dispersion of $\hat{x}_{i0}$ across individuals and across sessions, and for the first session of each economy, across economies. Hypothesis: the dispersion is largest across economies and across individuals for the first session.
    1.2. For sessions $j > 1$ ($j = 1$ is the first session), study dependence of $\hat{x}_{it}$ on x_t from the last period of the previous session.
2. Study distribution of $\{x_{it}\}_{i=1}^{N}$ across time within each session. Hypothesis: it gets tighter over time.
3. Fit adaptive expectations model for each individual:

$$\hat{x}_{it} - \hat{x}_{it-1} = (1 - \lambda_i)\,(y_{t-1} - \hat{x}_{it-1}) + \text{residual}_{it}$$

   Also fit a pooled version of this (imposing the same λ) across all individuals i.
4. With the pooled estimate of λ, study whether the Phelps problem *predicts* the smooth downward trajectories toward Ramsey.

6. Concluding Discussion

Before our experiments, we were skeptical that chanting 'just do it' would solve the time consistency problem posed by an expectational Phillips curve. Our experiments have softened but not fully arrested our skepticism. A supermajority of experimental sample paths show the monetary authority gradually reaching for the Ramsey value. Maybe this reflects the working of the 'just do it' spirit. We think it more probable that it reflects a Phelps-Cho-Matsui monetary authority who imputes an 'induction hypothesis'[7] to the private forecasters, and who sets out to manipulate those expectations by its actions. However, there are more than enough deviations from Ramsey for us not to take the solution of the time consistency problem for granted. In addition to occasional backsliding – predicted by the mean dynamics associated with least squares learning of a self-confirming equilibrium – our experimental economy can be stuck with an incompetent policy maker.

[7] I.E., adaaptive expectations.

Appendix A.
Instructions for Policy Maker

Today you will participate in an experiment in economic decision making. Various research foundations have provided funds for the conduct of this research. The instructions are simple, and if you follow them carefully and make good decisions you can earn up to $20 that will be paid to you in cash at the end of this experiment.

You will be assigned a role of a policy maker. In each period of the experimental economy, your job will be to choose the target inflation rate. As a policy maker, you are concerned about the values of inflation and unemployment. However, you can directly affect only the inflation rate.

You will play a series of experimental sessions. An experimental session will consist of a number of experimental periods. At the beginning of each period of an experimental session, you will be asked to choose the target inflation rate. The actual inflation rate will then be determined by adding a stochastic shock to the target inflation rate. This reflects the fact that you, as the policy maker, do not have complete control over the inflation rate.

The stochastic shock is normally distributed and has the mean value equal to 0 and the standard deviation equal to 0.3. This means that approximately 68% of the values of the shock will be between -0.3 and 0.3. In addition, approximately 95% of the values will be between -0.6 and 0.6. Almost all the values, 99.7%, will be between -0.9 and 0.9

At the beginning of each time period, private agents will forecast the inflation rate for that time period.

At the end of each experimental period, you will see the average forecasted inflation rate (averaged over the forecasts of all private agents) on your computer screen. You will also see the actual rate of inflation and the rate of unemployment for that experimental time period.

The actual inflation rate and the average forecasted inflation rate play the role in determining the rate of unemployment in the economy. The rate of unemployment is calculated in the following way:

$$\text{unemployment} = u^* \text{ - (inflation - av. forecasted inflation) + shock}$$

where u^* is the *natural rate of unemployment* which prevails in the economy if the actual rate of inflation is equal to average forecasted inflation rate, *av. exp. inflation* is the rate computed as the average of private agents' expected rates, and *shock* is a stochastic shock normally distributed, with mean value 0 and the standard deviation equal to 0.3.

At the end of every experimental period, you will also see the payoff that you earned in that period. The payoff is calculated in the following way:

$$\text{payoff} = -\,0.5\ (\ \text{inflation}^2 + \text{unemployment}^2\ ).$$

Thus your payoff decreases with increases in both the inflation and unemployment.

At any given experimental period, the probability that the current session continues for one more period is equal to 0.98. Whether or not the session is played for one more period is determined in the following way. A random number between 0 and 1 is drawn from a uniform distribution. If the number is less or equal to 0.98, the current session continues into the next period. If the number is greater than 0.98, the session is over. This number will appear in the last column of your screen at the end of each experimental time period. Once the number randomly drawn is greater than 0.98, the session will be automatically terminated.

You will start every experimental session by running a computer program. The experimenter will give you the name of the program.

Once you start the program, you will be prompted to enter the session number. You will enter these numbers in the consecutive order, starting with 1 for the first session, 2 for the second, etc.

After entering the session number, you will be prompted to enter the probability that a particular session ends at any given experimental time period. Enter the number 0.98 for this question. Once you answer thesetwo questions, an experimental session begins.

Earnings

The experiment will last for two hours. If you complete this 2-hour experiment, you are guaranteed to receive a $10 payment. Moreover, you can earn additional $10, for a total of $20.

At the end of each session, a *probability of winning a prize* of additional $10 will be computed in the following way.

1. For every time period of the session, the number *period points* is calculated by adding 100 points to the payoff that you obtained in that time period.

2. The number *total points* is calculated by adding up the period points earned in all time periods of a given experimental session. If this number turns out to be less than 0, it is set equal to 0.

3. The number *max points* is calculated by multiplying the total number of periods of the session by 100. This number is the number of total points that you would earn in an experimental session if your payoff were equal to 0 in every experimental period.

4. The probability of winning the prize is then calculated in the following way:

$$1 - (maxpoints - totalpoints)\,/maxpoints.$$

Table B.1 1 presents an example of how the total points, maxpoints, and the probability are calculated in a hypothetical experimental session. The length of session is 5 experimental periods.

period	payoff	*period points*
1	-20.25	79.75
2	-115.25	- 15.25
3	-5.16	94.84
4	-10.37	89.63
5	-30.25	69.75
total points		318.72

$maxpoints = 100 \text{ x } 5 \text{ periods} = 500$

Thus, the probability of winning the prize in this session is:

$$1 - \frac{(500 - 318.72)}{500} = 0.64$$

Note that higher values of your payoff in each time period (lower in absolute terms) result in higher period and total points. Higher values of total points result, in turn, in higher probability of winning the prize.

5. If your total points happen to be less than zero, then your probability of winning the prize in that session is set equal to zero.

At the end of the experiment, one of the sessions that you played will be randomly selected. Each session will have *equal chance* of being selected. The session will be selected by running the program *draw.exe* at the DOS prompt.

Once you type *draw* and press enter, you will be asked to enter your id number. Your *id* number as the policy maker is 5. Once you entered it, you will be prompted to enter the total number of sessions played in the experiment. When you enter this number, the computer will randomly choose a number between 1 and the *number of sessions* played. This number will appear on your computer screen and will indicate the number of the selected session.

The second number that will appear will be the number between 0 and 1, *rand*, drawn from the uniform distribution. You will take that number and compare it to the probability of winning the prize for the selected session.

If *rand* is less or equal to the probability of winning a lottery, you win additional \$10.00. If *rand* is greater than the probability, you do not win the additional \$10.00 prize. Thus the higher the probability of winning the prize, the higher your chances that *rand* will be less or equal to the probability.

ARE THERE ANY QUESTIONS?

Appendix B. Instructions for forecasters

Today you will participate in an experiment in economic decision making. Various research foundations have provided funds for the conduct of this research. The instructions are simple, and if you follow them carefully and make good decisions you can earn up to \$20 that will be paid to you in cash at the end of this experiment.

You are assigned a role of a private agent whose task is to forecast the rate of inflation in the economy in each experimental time period. The target inflation rate in the economy is set by a policy maker.

The actual rate of inflation is determined by adding a stochastic shock to the target inflation rate which reflects the fact that the policy maker does not have the total control over the inflation rate. The shock is normally distributed and has the mean value equal to 0 and the standard deviation equal to 0.3 This means that approximately 68% of the values of the shock will be between -0.3 and 0.3. In addition, approximately 95% of the values will be between -0.6 and 0.6. Almost all the values, 99.7%, will be between -0.9 and 0.9

Your payoff will depend on how close your forecast is to the actual rate of inflation.

You will play a series of experimental sessions. An experimental session will consist of a number of experimental periods. At the beginning of each experimental time period, you will be prompted to forecast the inflation rate. At the end of each experimental period, you will see the actual rate of inflation and the rate of unemployment for that time period on your computer screen.

At the end of every experimental period, you will also see your payoff for that period. The payoff is given by:

$$\text{payoff} = -\,5\times(\text{inflation} - \text{forecast})^2.$$

Thus the higher the squared difference between the actual rate of inflation and your forecast, the lower your payoff.

At any given experimental period, the probability that the session continues for another period is equal to 0.98. This will be determined in the following way. A random number between 0 and 1 will be drawn from a uniform distribution. If the number is less or equal to 0.98, the current session continues into the next period. If the number is greater than 0.98, the session is over. This number will appear in the last column of your screen at the end of each experimental time period. Once the number randomly drawn is greater than 0.98, the session will be automatically terminated.

You will start every experimental session by running a computer program. The experimenter will give you the name of the program. At the beginning of the experiment you will be assigned your identification number. You will keep the same identification number in all experimental sessions and will be prompted to type it at the start of each session. You will also be prompted to enter the probability that the session will end. Enter 0.98 for this question.

Earnings

The experiment will last for two hours. If you complete this 2-hour experiment, you are guaranteed to receive a $10 payment. Moreover, you can earn additional $10, for a total of $20.

At the end of each session, a *probability of winning a prize* of additional $10 will be computed in the following way.

1. For every time period of the session, the number *period points* is calculated by adding 100 points to the payoff that you obtained in that time period.

2. The number *total points* is calculated by adding up the period points earned in all time periods of a given experimental session. If this number turns out to be less than 0, it is set equal to 0.

3. The number *max points* is calculated by multiplying the total number of periods of the session by 100. This number is the number of total points that you would earn in an experimental session if your payoff were equal to 0 in every experimental period.

4. The probability of winning the prize is then calculated in the following way:

$$1 - (maxpoints - totalpoints)\,/maxpoints.$$

Table A.1 presents an example of how the total points, maxpoints, and the probability are calculated in a hypothetical experimental session. The length of session is 5 experimental periods.

period	payoff	*period points*
1	-20.25	79.75
2	-115.25	- 15.25
3	-5.16	94.84
4	-10.37	89.63
5	-30.25	69.75
total points		318.72

$maxpoints = 100$ x 5 periods $= 500$

Thus, the probability of winning the prize in this session is:

$$1 - \frac{(500 - 318.72)}{500} = 0.64$$

Note that higher values of your payoff in each time period (lower in absolute terms) result in higher period and total points. Higher values of total points result, in turn, in higher probability of winning the prize.

5. If your total points happen to be less than zero, then your probability of winning the prize in that session is set equal to zero.

At the end of the experiment, one of the sessions that you played will be randomly selected. Each session will have *equal chance* of being selected. The session will be selected by running the program *draw.exe* at the DOS prompt.

Once you type *draw* and press enter, you will be asked to enter your id number. Once you entered it, you will be prompted to enter the total number of sessions played in the experiment. When you enter this number, the computer will randomly choose a number between 1 and the number of sessions played. This number will appear on your computer screen and will indicate the number of the selected session.

The second number that will appear will be the number between 0 and 1, *rand*, drawn from the uniform distribution. You will take that number and compare it to the probability of winning the prize for the selected session. If *rand* is less or equal to the probability of winning a lottery, you win additional $10.00. If *rand* is greater than the probability, you do not win the additional $10.00 prize. Thus the higher the probability of winning the prize, the higher your chances that *rand* will be less or equal to the probability.

ARE THERE ANY QUESTIONS?

Appendix C.
Figures

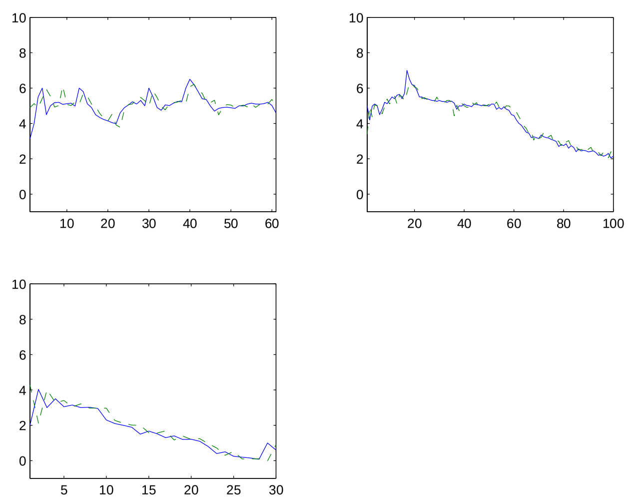


Figure C.1: Economy 1. The $\hat{x}_t$ (dotted) and x_t solid.

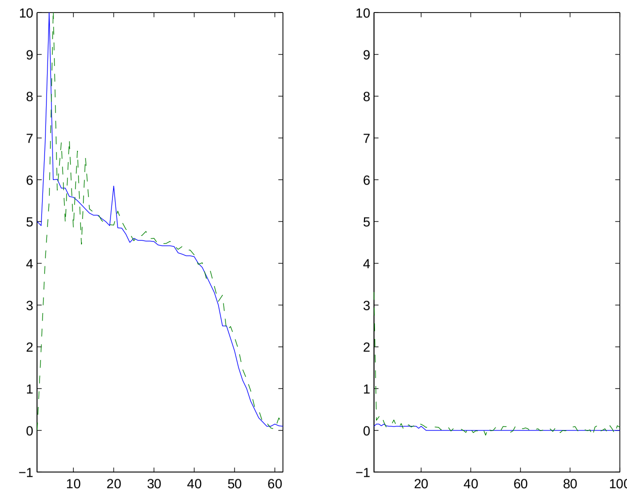


Figure C.2: Economy 2. The $\hat{x}_t$ (dotted) and x_t solid.

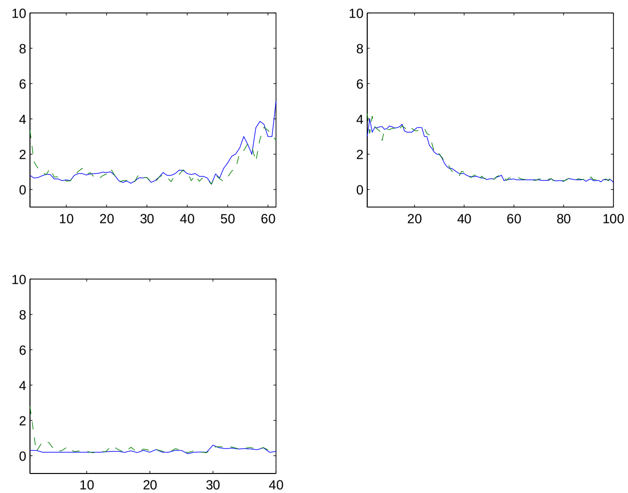


Figure C.3: Economy 3. The $\hat{x}_t$ (dotted) and x_t solid.

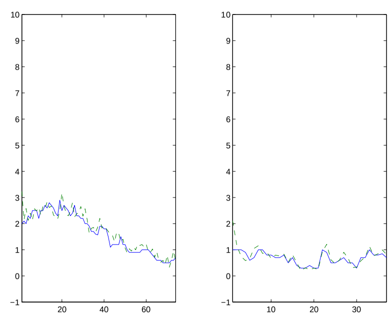


Figure C.4: Economy 4. $\hat{x}_t$ (dotted) and x_t (solid).

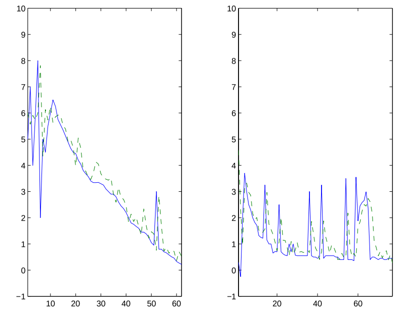


Figure C.5: Economy 5. $\hat{x}_t$ (dotted) and x_t (solid).

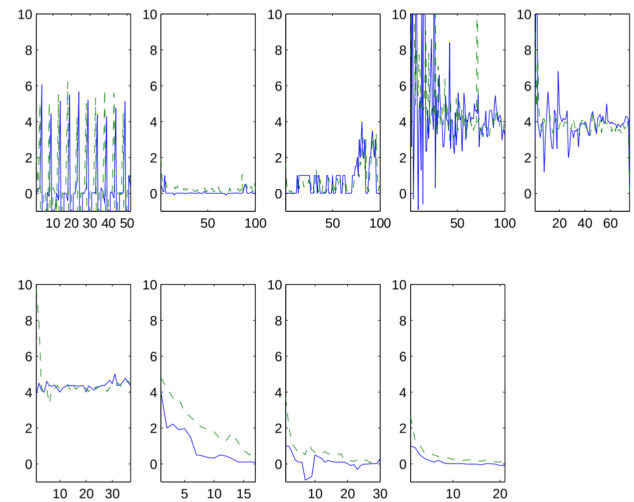


Figure C.6: Economy 6. $\hat{x}_t$ (dotted) and x_t (solid).

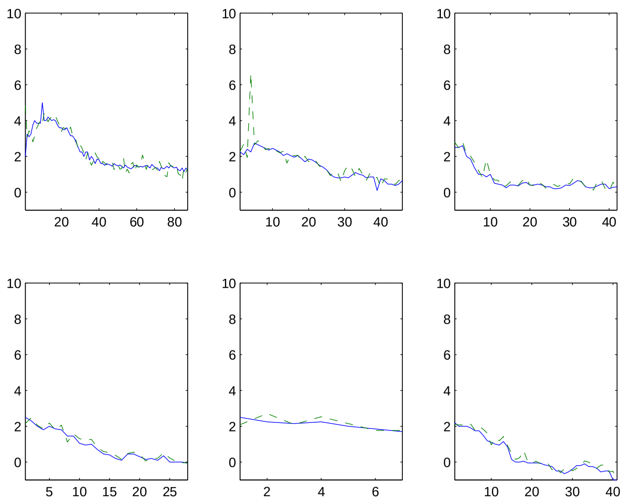


Figure C.7: Economy 7. $\hat{x}_t$ (dotted) and x_t (solid).

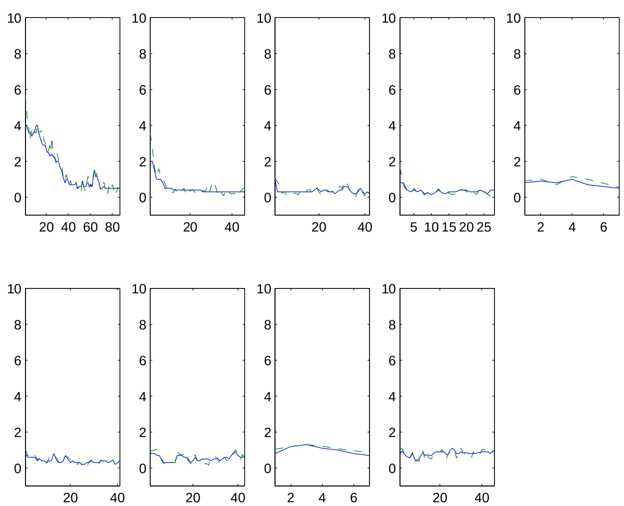


Figure C.8: Economy 8. $\hat{x}_t$ (dotted) and x_t (solid).

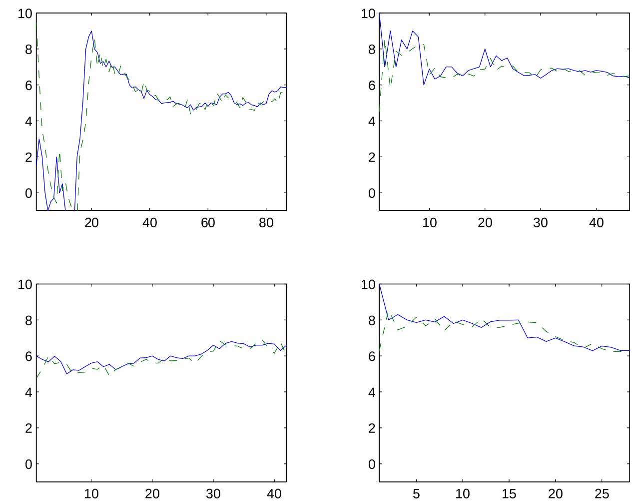
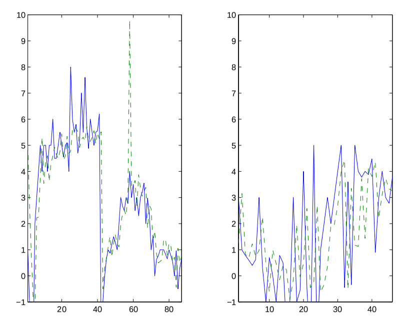


Figure C.9: Economy 9. $\hat{x}_t$ (dotted) and x_t (solid).



$\hat{x}_t$ (dotted)

Figure C.10: Economy 10. and x_t solid.

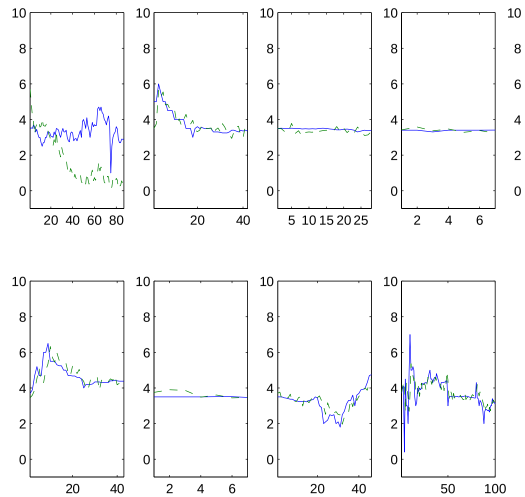


Figure C.11: Economy 11. $\hat{x}_t$ (dotted) and x_t (solid).

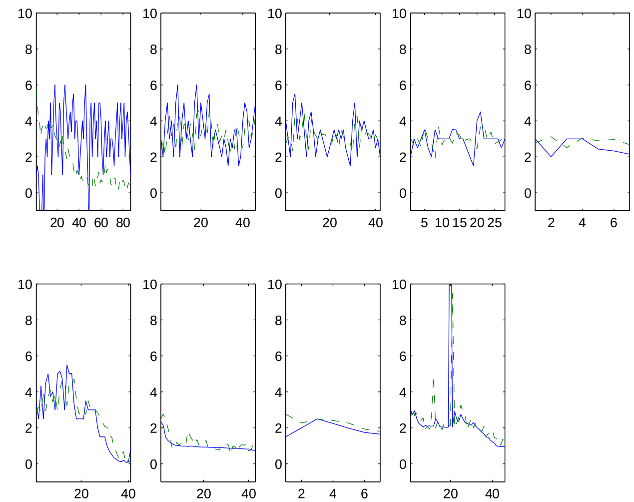


Figure C.12: Economy 12. $\hat{x}_t$ (dotted) and x_t (solid).

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