Why Stable Fiat Money Hyperinflates: Results from an Experimental Economy

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Experiments are used to study the acceptance of fiat money as a medium of exchange in a two good circular flow economy. In these markets money has a finite life, yet people are willing to trade valuable goods for the intrinsically worthless shinplaster. Inflation remains low to moderate depending on the relatively long or short life span of the currency. However, when a public sector capable of printing money is introduced, the private sector is crowded out, producing dramatic hyperinflations that lead to a collapse in trading. This is shown to be a consequence of the public sector, with its reliance on the printing press, subverting the two-sided price discovery process and not the result of the increasing money supply. Comparing economies without a public sector that experience exogenous monetary growth to economies with a public sector, the private markets are found to have similar inflation but significantly greater efficiency even though the money supply is expanding at the same rate in both systems. This analysis supports the rational expectations hypothesis that peoples' behavior patterns will vary with changes in government policies.

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Fiat money is a convention that allows individuals to complete trades without relying on coincidence of wants or requiring the sub-optimal use of commodities as money. In order for individuals to accept the intrinsically worthless money in exchange for valuable goods, the agents must believe that the money can be used to purchase other items of even greater value. An economic collapse occurs when agents loose faith in the money's ability to make such future purchases. One theoretical cause for the unraveling of a money's value is a finite circulation horizon for the currency. However, the resulting autarky leaves all agents receiving strictly worse payoffs than they would have achieved if everyone had continued to accept the money. Hence, in the finite horizon there are two countervailing forces affecting money's acceptability. Examples of stable fiat monies abound, including national currencies and privately issued monies. However, fiat money can rapidly become unstable as evidenced by observed historical hyperinflationary episodes. Through the use of experimental methods, this research seeks to identify what factors determine if a fiat money can provide a stable medium of exchange.

The following section identifies the factors of interest and details an experimental economy. A separate section presents the experimental results that demonstrate fiat money's acceptance as a medium of exchange in a finite horizon, except when the public sector is actively corrupting the trading process. Another section offers econometric estimation in support of these findings. The final section contains concluding remarks.

Experimental Design

Hyperinflationary episodes reveal the inherent instability of fiat currencies and hence provide insight into the factors affecting its acceptance. Our experimental design is motivated by Capie (1986) who studies several historic incidences of hyperinflation

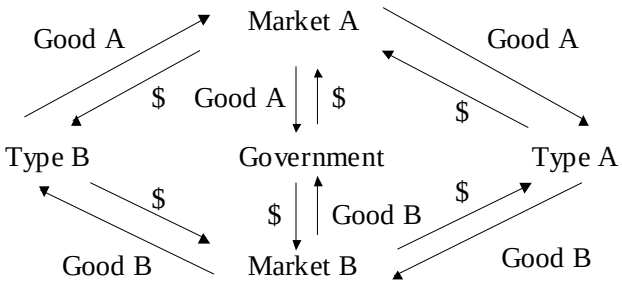
and finds three common elements; the use of a fiat money, government spending financed through the use of the printing press, and civil unrest. Thus we begin our analysis of fiat money's acceptability by comparing economies trading in backed money to economies employing fiat money. Next we turn our attention to the two treatment variables identified by Capie (1986). We examine the behavior of the government by varying between economies with no government, economies with an active government that has the ability to purchase items through the "printing" of money, and economies with exogenous growth in the money supply. The second treatment variable is the length of the monetary regime, which serves as a proxy for the level of civil unrest. When civil unrest is high, the expected duration of the current monetary regime is short. In contrast, when civil unrest is low, the expected duration of the monetary regime is much longer. By systematically controlling these factors, our laboratory experiments provide insight into the acceptance of fiat money that cannot be attained from field data due to the lack of complete information and replicability available in the naturally occurring economy.

Experimental Economy

The experimental economy is described by the circular flow diagram shown in Figure 1. Type A agents purchase units of Good A with the experimental currency called "tickets." Additionally, type A agents can sell their endowed units of Good B for tickets. Similarly, type B agents purchase units of good B paying with tickets and sell units of good A in return for tickets.[1] In the treatments involving an active government, type G agents, the central links of the economy are added.

[1] This design is an extension of preliminary work reported in McCabe (1987).

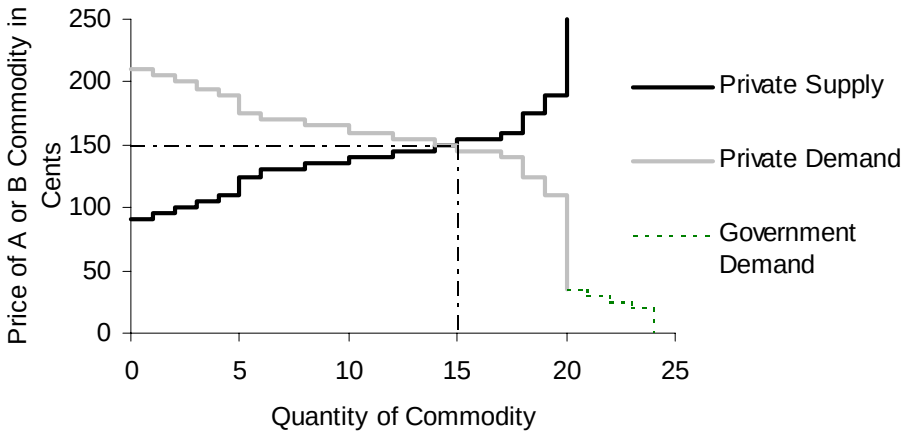
Figure 1: Experimental Economy



Type G agents demand both goods but supply neither good. While type A and B agents are endowed with money, they must sell their endowment goods in order to acquire additional tickets with which to make purchases. Type G agents face no such restriction, instead being able to create an unlimited supply of tickets.

Real market conditions for both goods are characterized by the induced demand and supply curves depicted in Figure 2.

Figure 2: Supply and Demand per Day



The height of the demand curve represents the induced value in US cents of a unit of good A or B and the height of the supply curve represents the induced cost in US cents of a unit of the good. The values and costs are induced as the subjects' payoffs are incremented and decremented, respectively, by the given amount if they trade. Supply and demand curves denominated in the experimental currency are based on the conversion rate, λ, of tickets into US currency. Therefore, Figure 2 also shows the nominal supply and demand conditions for λ=1 cent. The real market clearing price, $1.50, and equilibrium quantity, 15, are readily observable from this figure. More generally, the nominal daily equilibrium prices for both goods are $150/\lambda$, when $\lambda>0$. The total surplus is $7.50 in each market and is distributed evenly among the five type A and five type B agents in the economy. Thus in equilibrium type A and type B agents each earn $1.50 trading profit, calculated as the value of goods purchased minus the cost of goods sold, per day. Notice that the units demanded by the government agents are not produced in equilibrium. Also, since the worth of the government's most valuable unit is below the lowest cost of any seller, there will be an efficiency loss whenever the government agents make a purchase.

Agents bought and sold goods through double auction institutions[2] operating simultaneously in each market by posting willingnesses to buy or sell at ticket prices. Each trading period is referred to as a "day." A subject's values and costs were reinitialized at the beginning of each day; that is subjects could buy and sell the same units each trading day. Subjects retained the same locations along the demand and supply curves throughout the experiment. Tickets circulated in the economy for a given

number of days, the duration of which was referred to as a "week." At the beginning of a week, type A and B subjects were given an endowment, ω, of tickets. As they traded, their ticket balances reflected these transactions. Type A and B agents were not allowed to hold negative ticket balances at any point in the experiment. A subject's ticket balances were carried forward until the completion of the last trading day of the week at which time the remaining balances was converted into monetary payoffs at the rate λ. Thus when the exchange rate is positive, tickets are a commodity or backed money, but when $\lambda = 0$ the currency is a pure fiat money. Type G agents were not endowed with money and instead could create money at a cost of λ per ticket.[3]

In the experiments, a short horizon regime lasted for a two day week, while a long horizon regime endured for either 4 or 8 days.[4] In the inactive government treatments, only the five type A and five type B agents conducted trade in the economy. The active government was introduced into the experiments by including two additional subjects, each demanding two units in each market, as shown in Figure 2. During the experiments no references were made to government, the printing press, or money to avoid any influence from preconceived notions the subjects may have had about these institutions.

Procedures

Seventeen computerized experiments were conducted at the Economic Science Laboratory using University of Arizona undergraduate students as subjects. Each

[2] A double auction institution was employed due to its demonstrated success in achieving equilibrium in other market situations. See Smith and Williams (1982), Ketcham, Smith and Williams (1984), Williams, Smith, Ledyard, and Gjerstad (2000) and Deck (2001).

[3] As the endowment of tickets represents a loan from the experimenter, the $US value of the endowment was deducted from subjects' payoffs at the end of the week. The loan, equal to $\lambda \times \omega$, was identical for all type A and B agents each week. Type G agents did not have a loan repayment.

[4] All long horizon sessions went to an eight day week after an initial backed money phase. Time constraints then dictated the duration of the remaining weeks.

computerized experiment ran for a total of four hours over the course of two calendar days. On the first calendar day, subjects read instructions[5] and participated in a training session consisting of one day horizons. During the training session subjects experienced ticket redemption values varying between λ = .25 and λ = 2 US cents per ticket. By varying λ, behavioral changes that occur when the money's backing is removed are attributable to the use of fiat money and not simply an exchange rate change.

The second calendar day consisted of subjects rereading the instructions and then participating in the experiment. In every experiment the initial weeks consisted of two days with the value of a ticket backed at the rate λ=1. All sessions quickly converged towards the equilibrium prediction, P_A=P_B=150. Therefore, each session had the same initial conditions and the impact of the various treatments can be interpreted as deviations away from this focal point. ω was set equal to 400 tickets each time a new regime was implemented. Hence, private agents faced a liquidity constraint as they should trade three units of each good per trading day in equilibrium.

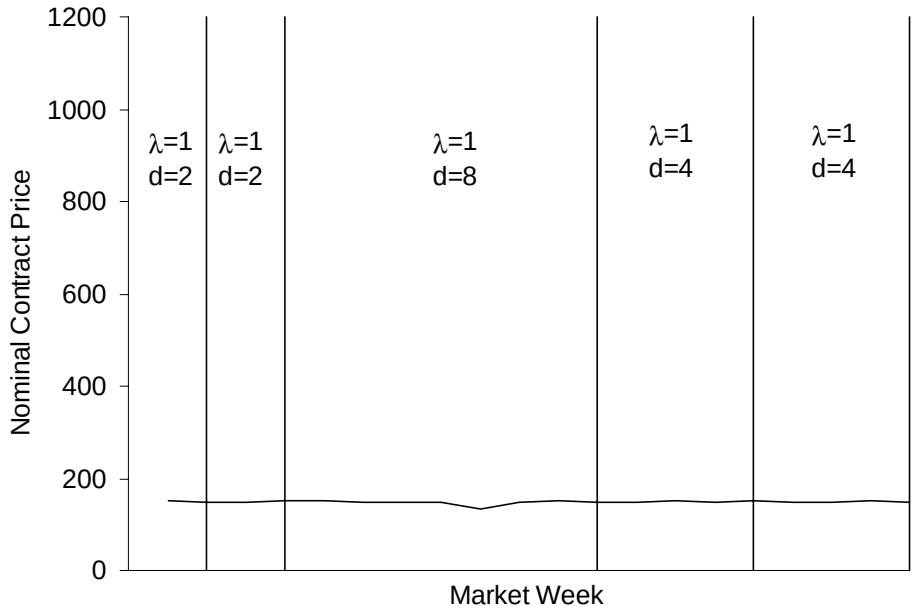
At the conclusion of the experiment subjects were privately paid their earnings from the training session and the actual experiment as well as a $15 participation fee. A subject's earnings consisted of the summation of weekly profits from both the experiment and the training session, thus alleviating the impact that negative period profits might have on subject incentives.

Results

The data consist of bids, asks, and acceptances in both markets for each of the sessions, three sessions under each of the five fiat money treatments and the two backed

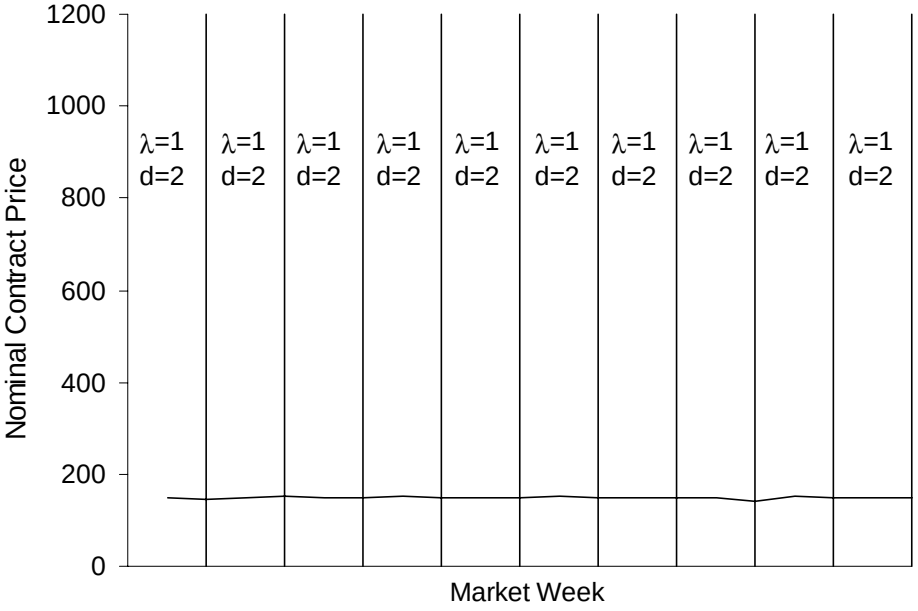
[5] A copy of the directions is available form the authors upon request.

Figure 3: Quantity Weighted Average Contract Prices by Session in Long Horizon Backed Money



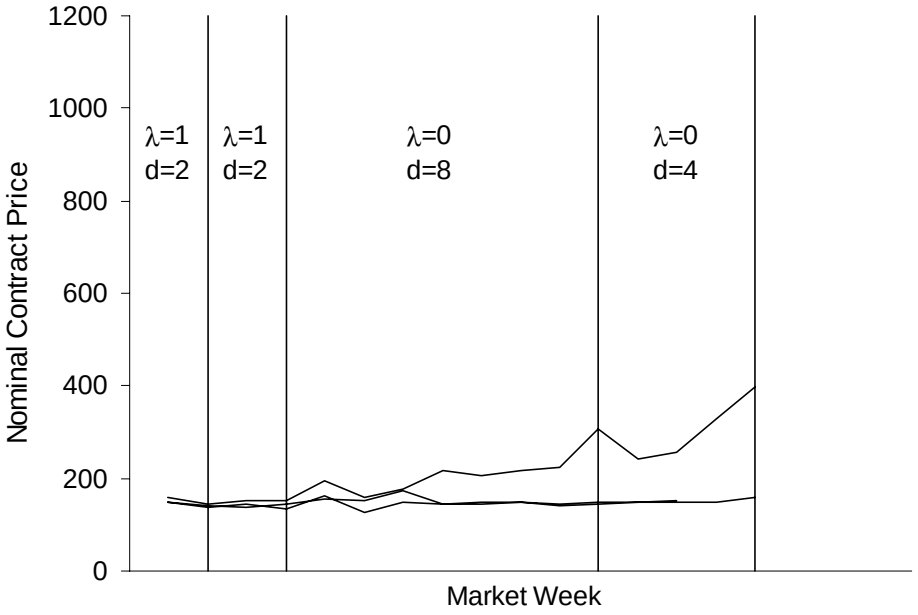
λ is the exchange rate and d is the number of trading days in the week.

Figure 4: Quantity Weighted Average Contract Prices by Session in Short Horizon Backed Money



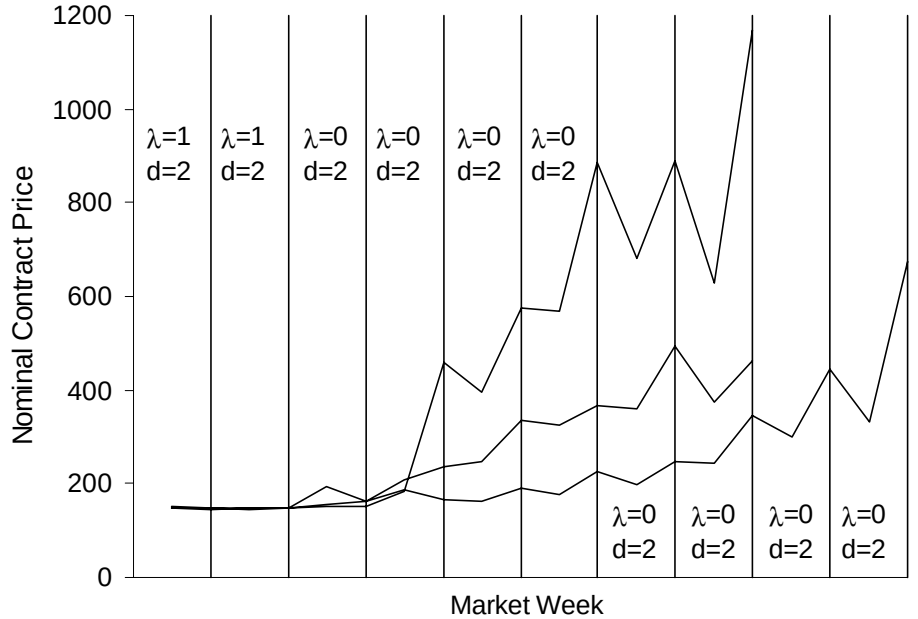
λ is the exchange rate and d is the number of trading days in the week.

Figure 5: Quantity Weighted Average Contract Prices by Session in Long Horizon Fiat Money



λ is the exchange rate and d is the number of trading days in the week.

Figure 6: Quantity Weighted Average Contract Prices by Session in Short Horizon Fiat Money



λ is the exchange rate and d is the number of trading days in the week.

money sessions. Figures 3-6 display the daily average nominal contract price by session for the backed and fiat money treatments with both long and short horizons. Using backed money the average prices remain near the equilibrium level regardless of the horizon. In the fiat money long horizon treatment the average nominal prices remain nearly constant throughout the experiment. Notice that these prices are centered on the equilibrium price from the initial weeks with backed money even though nominal prices are irrelevant in this setting. This is likely the result of subjects having discovered that prices in this range allowed them to reap the gains from trade in the initial backed money weeks. However, when the monetary horizon is short, nominal prices do begin to increase, but only after participants experience the termination of multiple fiat regimes. From these pictures it is evident that fiat money can provide a stable medium of exchange but that the level of inflation is dependent on the horizon.

Table 1 shows the total number of trades each day, averaged across sessions, for all seven treatments. Recalling that the equilibrium quantity under backed money is thirty units, the same pattern is again discernible where fiat money serves as medium of exchange allowing agents to coordinate and complete the same desired real transactions as in the backed money regimes. This ability is hampered by a short horizon potentially due to the repeated experience with money expiration. However, even repeated experience with the end of the horizon is not sufficient to force the economy to fully unravel.

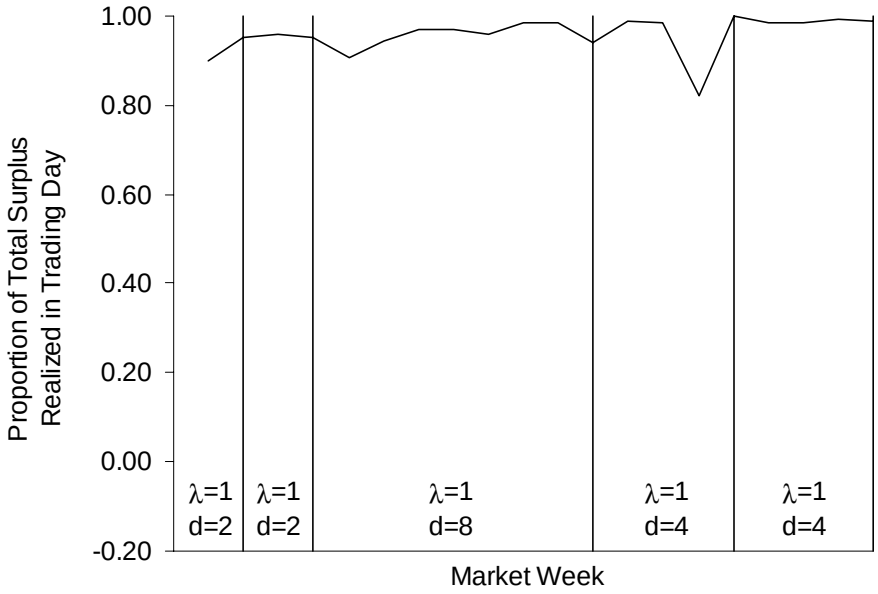
Table 1: Average Number of Contracts
Comparison by Treatment Averaged by Session

Day	Backed Money Long Horizon	Backed Money Short Horizon	Fiat Money Long Horizon	Fiat Money Short Horizon	Active Government Long Horizon	Active Government Short Horizon	Exogenous Money Growth
1	22	29	21	24	24	21	19
2	25	31	23	27	25	22	23
3	25	30	25	26	26	22	24
4	24	33	25	26	25	22	24
5	24	32	21	20	25	20	20
6	24	30	20	18	27	20	23
7	26	29	18	19	28	22	24
8	26	31	19	15	25	17	20
9	25	29	23	18	28	20	17
10	27	30	22	15	24	14	13
11	27	29	26	18	21	11	15
12	26	30	22	16	14	3	15
13	29	30	27	18	22		17
14	29	29	24	14	15		17
15	30	29	26	16	5		19
16	29	30	23	9	2		16
17	29	27		22			
18	28	29		15			
19	28	28		21			
20	28	28		12			

The first four market days of each session employed backed money at a rate $\lambda = 1$.

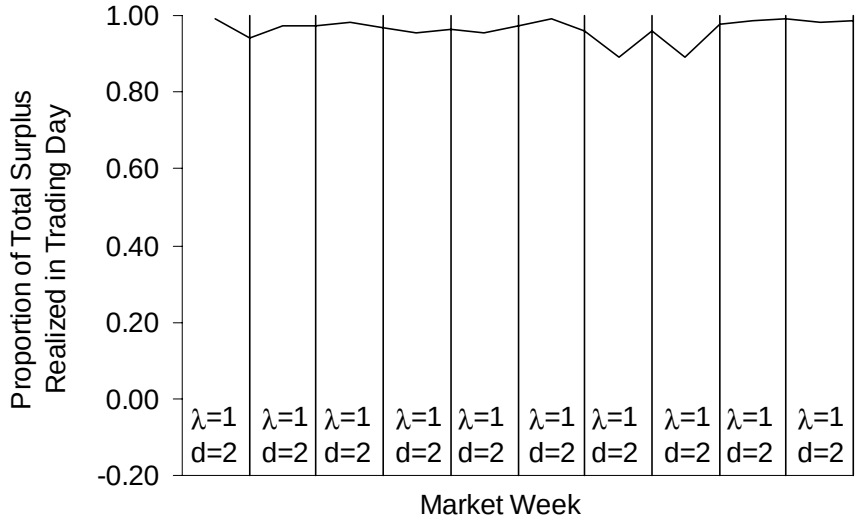
The maximum attainable surplus in the economy is twice the surplus of the market graphically represented in Figure 2 as the area between demand and supply. The economy's efficiency is calculated by adding the value net of cost for each unit traded. Notice that transaction prices do not affect market surplus. When trading occurs with backed money, contracts at nominal prices different from the theoretical prediction represent a transfer of surplus between agents, not a change in the level of surplus. Figures 7-10 graph economic efficiency for each of the treatments with a fixed money supply.

Figure 7: Daily Market Efficiency
by Session in Long Horizon Backed Money



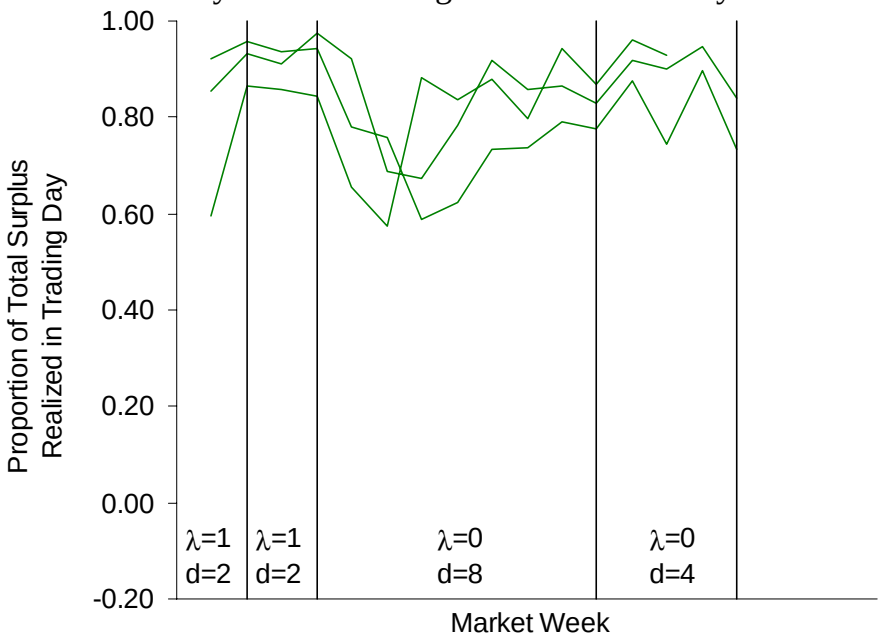
λ is the exchange rate and d is the number of trading days in the week.

Figure 8: Daily Market Efficiency
by Session in Short Horizon Backed Money



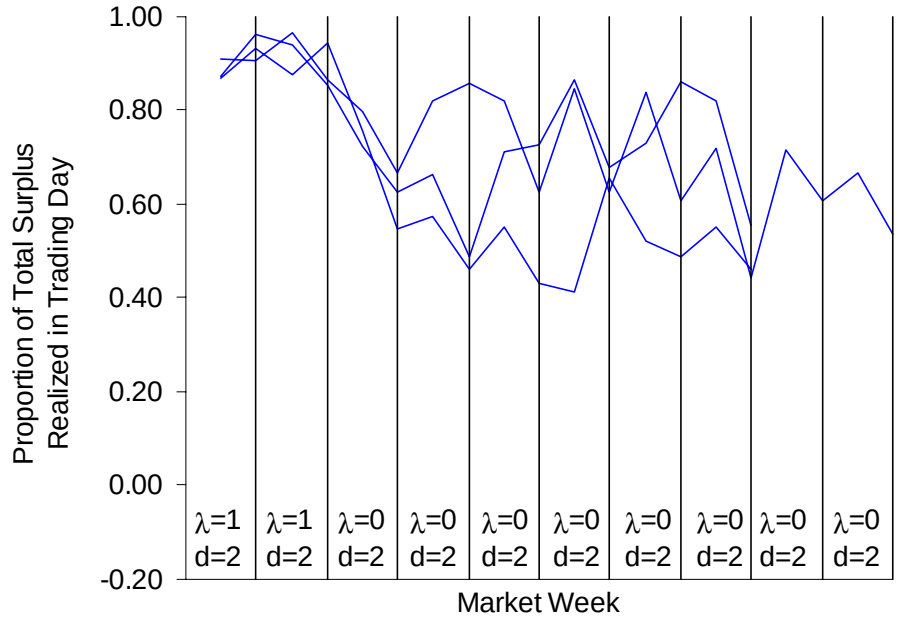
λ is the exchange rate and d is the number of trading days in the week.

Figure 9: Daily Market Efficiency
by Session in Long Horizon Fiat Money



λ is the exchange rate and d is the number of trading days in the week.

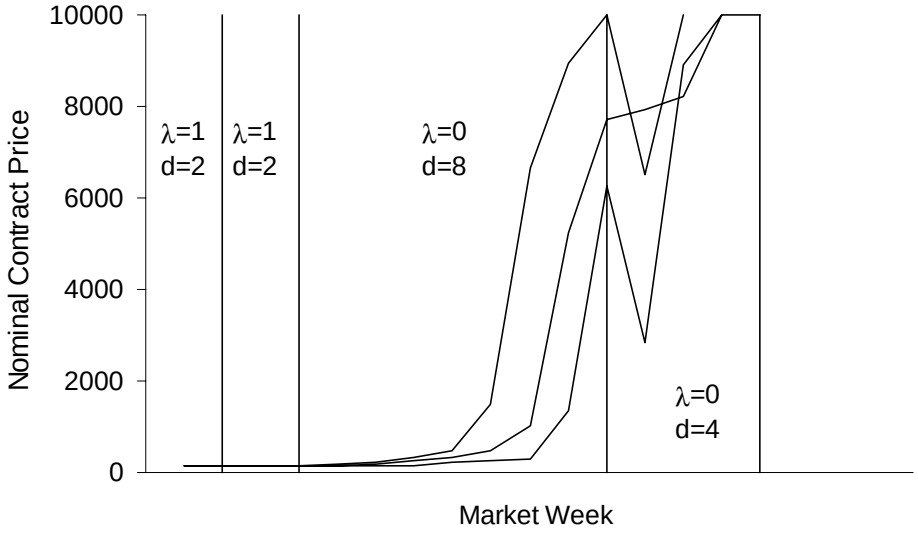
Figure 10: Daily Market Efficiency
by Session in Short Horizon Fiat Money



λ is the exchange rate and d is the number of trading days in the week.

Both backed money regimes and the fiat money long horizon regime attain high levels of efficiency, over 90% and 80% respectively, throughout the experiment. Again, a short horizon fiat money regime slightly destabilizes the economy, with observed efficiency around 65%. In contrast, when an active government is printing money to finance expenditures, the economy experiences a hyperinflation. Nominal prices experience tremendous increases, sometimes in the range of 2,000% between trading periods.[6] Nominal contract prices for the active government sessions are presented in Figures 11 and 12 for the long and short horizons respectively.

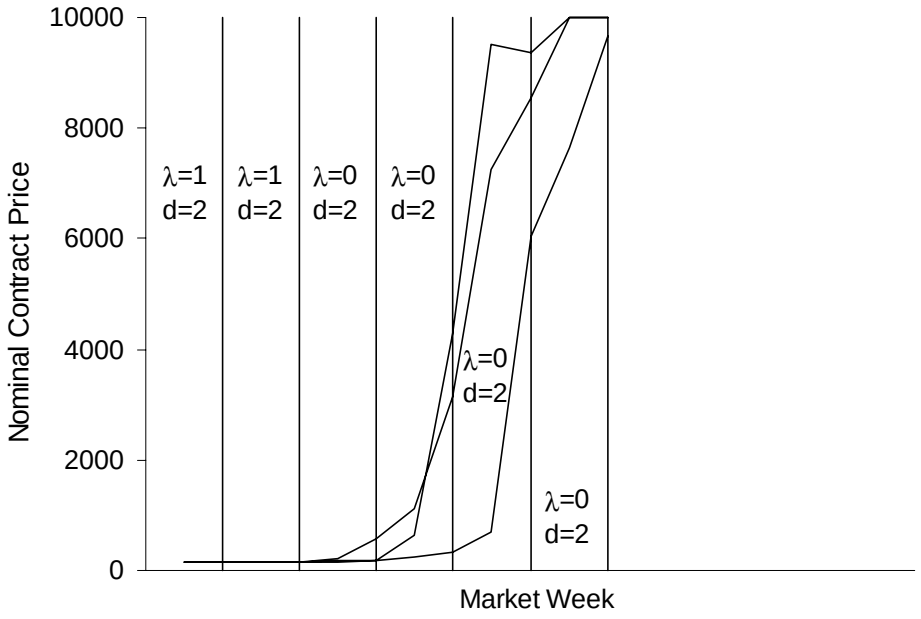
Figure 11: Quantity Weighted Average Contract Prices by Session in Long Horizon Active Government



λ is the exchange rate and d is the number of trading days in the week.

[6] This nominal behavior is comparable to historical field data. For example, German wholesale prices grew by 1.36×10^{14} between 1914 and 1924 and retail prices in Austria increased by 24,167% in the three and a half year period starting in January 1921.

Figure 12: Quantity Weighted Average Contract Prices by Session in Short Horizon Active Government

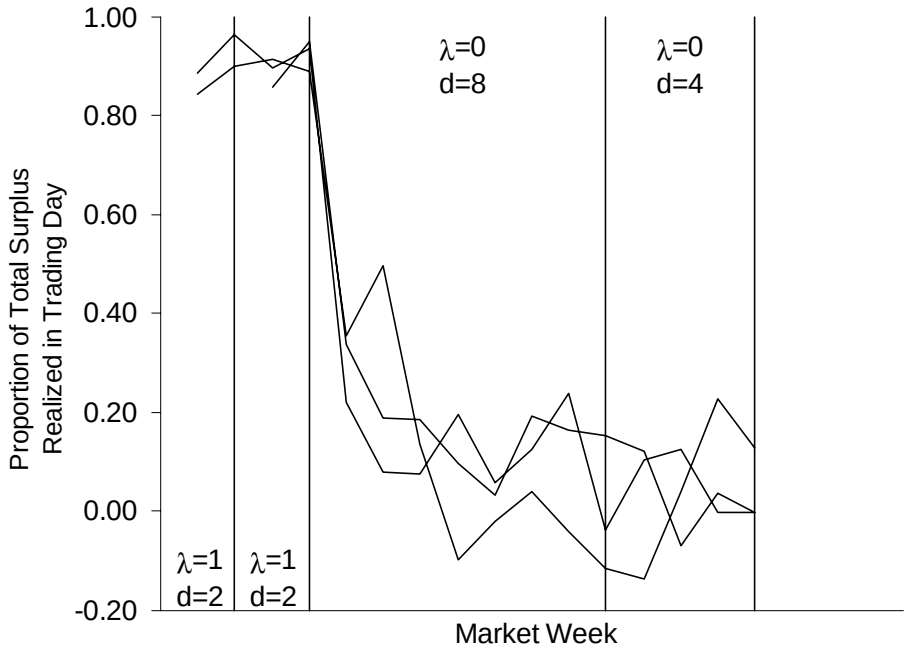


λ is the exchange rate and d is the number of trading days in the week.

Rapid growth in nominal prices is not debilitating if agents are able to sustain the real economy. Specifically, individuals who buy and sell the same number of units are equally as well off regardless of the nominal price level. However, the presence of a government also causes a sudden and dramatic collapse in the number of contracts, independent of the duration of the monetary regime as shown in Table 1.

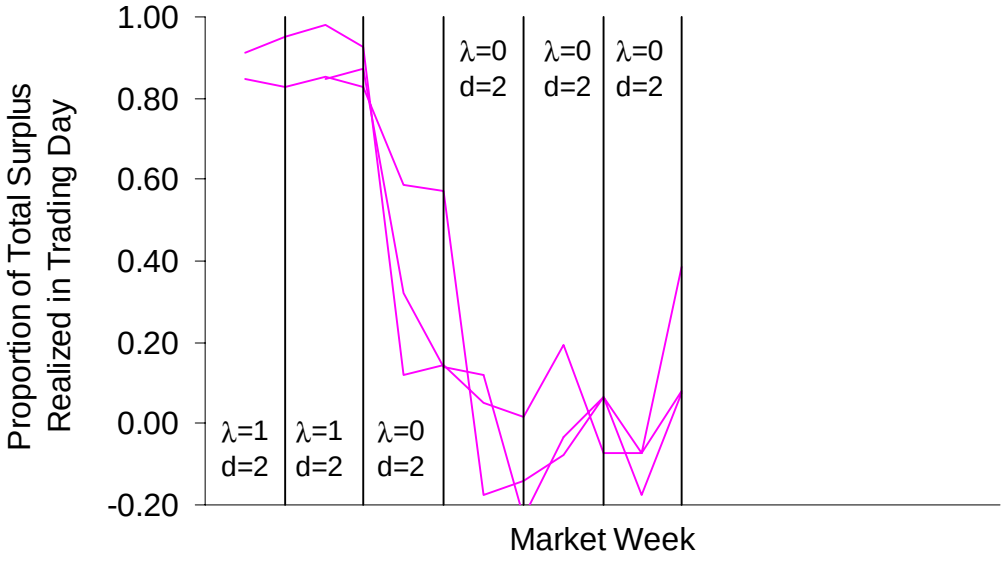
The same conclusions can be drawn from the efficiency calculations, which are exclusively within 15 percentage points of 0% after the first few trading days involving fiat money and an active government as shown in Figures 13 and 14.

Figure 13: Daily Market Efficiency
by Session in Long Horizon Active Government



λ is the exchange rate and d is the number of trading days in the week.

Figure 14: Daily Market Efficiency
by Session in Short Horizon Active Government

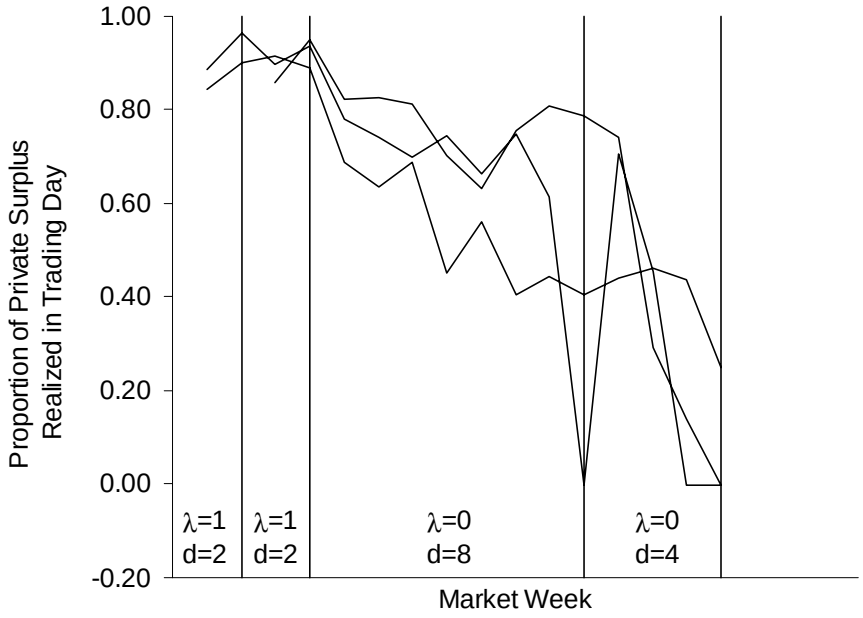


λ is the exchange rate and d is the number of trading days in the week.

Efficiency analysis of the treatments without an active government is straightforward. However, the market conditions employed in this experiment are admittedly such that any trade by the government involves efficiency reductions. It is this fact that allows achieved efficiency to be negative in some periods. Further, the level of government values somewhat arbitrarily determines the absolute size of this loss. Therefore, a more appropriate measure of the economy's performance is adjusted private efficiency. This rate is calculated as the percentage of the potential surplus available after the government crowding that the private sector of the economy is actually able to achieve. Formally, adjusted potential surplus is calculated by first removing from the supply curve the steps associated with units traded with type G agents. This adjusted supply curve is then compared to private demand to determine the potential private surplus. Adjusted private efficiency is calculated as the value net of cost for each unit traded between type A and B agents as a percentage of the potential private surplus. Adjusted efficiency is bounded between zero and one and is directly comparable to the efficiency calculations given for the other treatments. Figures 15 and 16 graph the adjusted efficiency for the active government sessions in the long and short horizons respectively. Even after adjusting for the government's crowding out of private wealth, the fundamental conclusion holds.

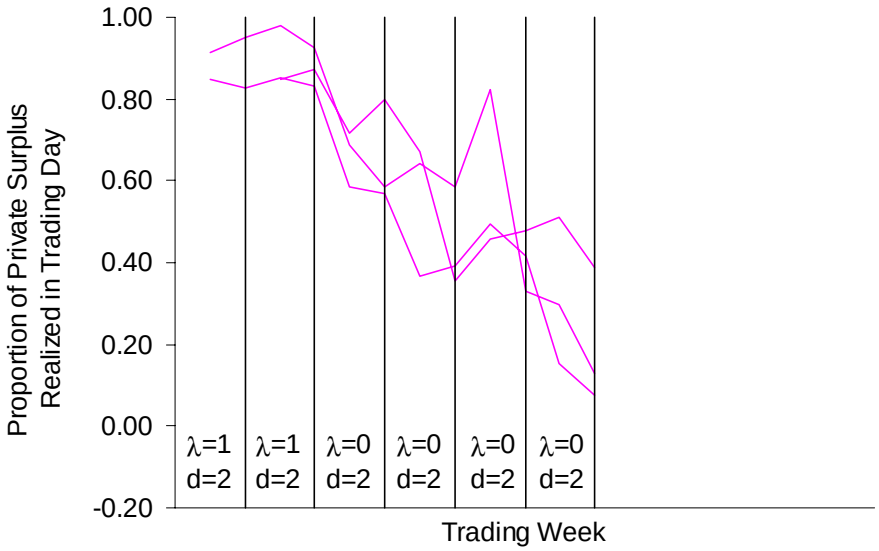
The impact government spending has on the economy is quite clear; prices escalate while trade volume and efficiency plummet. However, the experiments presented thus far do not identify the cause of this hyperinflation. There are two effects that an active government has on the economy. One is the increase in the money supply caused by the use of the printing press. The second effect is the government's free riding

Figure 15: Daily Adjusted Private Efficiency by Session in Long Horizon Active Government



λ is the exchange rate and d is the number of trading days in the week.

Figure 16: Daily Adjusted Private Efficiency by Session in Short Horizon Active Government



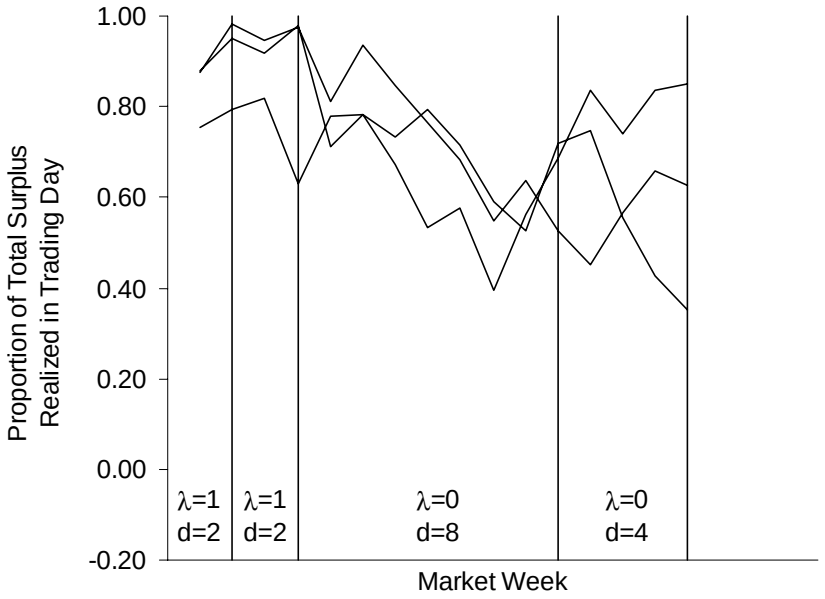
λ is the exchange rate and d is the number of trading days in the week.

on the price discovery process for the real underlying economy. To determine which of these two effects precipitates hyperinflation, another series of experiments was conducted in which the money supply exogenously grew during the trading horizon. Instead of money being introduced via government expenditures, in the exogenous money growth treatment each agent's money holdings were increased daily by a multiplier based on the observed growth rate of money in the long horizon active government treatment. Exogenous growth was only studied in the long horizon as this duration provided the greatest separation between the presence and absence of an active government.

The experimental results indicate that money growth is not the cause of the collapse in the economy. With the rapid exogenous growth in the money supply the number of contracts and the efficiency pattern are comparable to a short horizon no government fiat money regime as demonstrated in Table 1 and Figure 17 respectively. However, the increase in the money supply does generate an inflationary episode with respect to nominal prices. Figure 18 graphs average nominal prices, which inflate at the rate of growth in the money supply. Together these results indicate that the collapse in efficiency and trade volume are not the result of monetary behavior, but rather underlying government activity is driving the collapse. However, inflation is a monetary phenomenon.

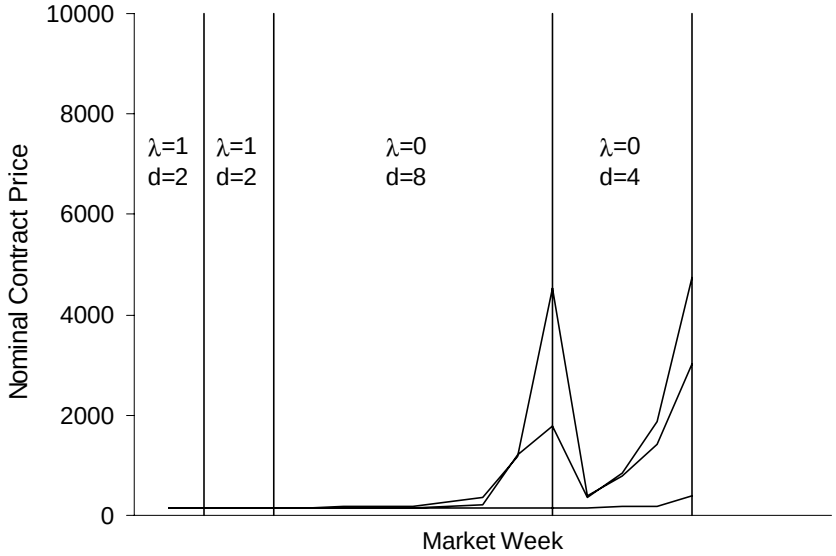
In order to maintain economic activity, individual agents must use the fiat money to conduct trades in the one real market in this environment, units of good A for units of good B. The nominal prices of the double auction institution can be converted into real bids and asks to explore this real price discovery process. The nominal bid in market A represents a willingness to spend money for good A, while the nominal ask in market B

Figure 17: Daily Market Efficiency
by Session in Exogenous Growth of Money



λ is the exchange rate and d is the number of trading days in the week.

Figure 18: Quantity Weighted Average Contract Prices by
Session in Exogenous Growth of Money



λ is the exchange rate and d is the number of trading days in the week.

represents a willingness to sell good B for money. Therefore, the ratio of the nominal ask in market B to the nominal bid in market A represents the willingness of market participants to purchase good A with units of good B, the real bid. Similarly, the determination of the real asking price for good A in terms of good B is the ratio of the bid in market A to the ask in market B.

For brevity, the real price discovery process is depicted for only four market days. Figures 19-22 present the real bids and asks for the last day of the first week in which fiat money was in circulation for a session in each of the four long horizon treatments; under backed money, during a fiat money session, when there is exogenous growth, and in the presence of an active government respectively. At some points in time there was no standing bids or asks in a market, so the most recent nominal price quotes were used to calculate the real bids and asks, which were truncated for values above two. It is the absence of a standing nominal bid or ask that allows the real bid to exceed the real ask in the following figures.

Figure 19: Real Bids and Asks
Long Horizon Backed Money

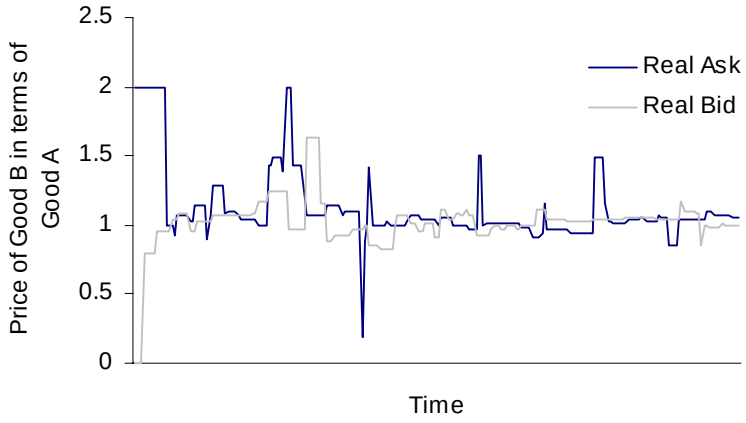


Figure 20: Real Bids and Asks
Long Horizon Fiat Money

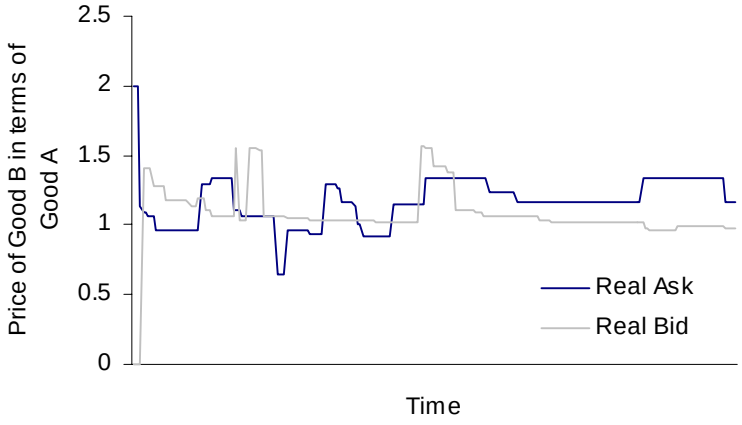
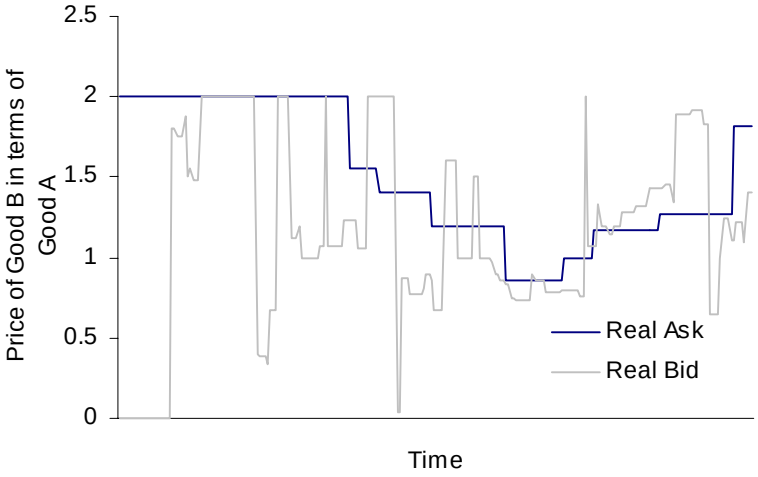
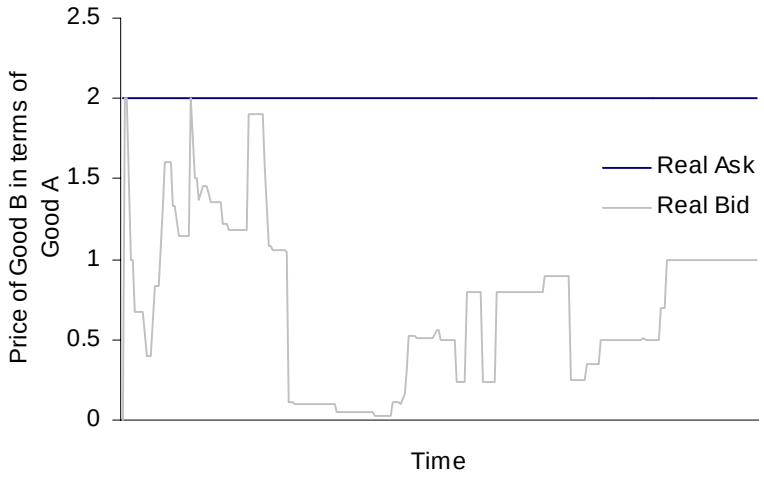


Figure 21: Real Bids and Asks
Exogenous Growth



As evidenced by Figure 19, when money is backed participants are actively seeking out the real price, which based on the market conditions of the economy is one in equilibrium. When subjects have gained experience trading in fiat money and there is no active government, the price discovery process is similar to the backed money environment as shown in Figures 20 and 21. However, when the government is active the process breaks down, as nominal prices no longer convey information about relative

Figure 22: Real Bids and Asks
Long Horizon Active Government



prices since the government stands ready to purchase at any nominal price. Once the government is active in the price discovery process, the double auction institution is no longer able to serve as a mechanism for coordinating economic activity. This corruption of the price discovery mechanism by the active government, shown in Figure 22, is what ultimately results in autarky.

Estimation

Econometric analysis based on the time series data for private efficiency confirms that while fiat money economies are not as stable as backed money systems, these economies significantly outperform unrestrained active government regimes. Each regime type is independently modeled as

$$\Pi_t=\alpha+\beta\Pi_{t-1}+\delta Initial_t+\varepsilon_t \quad (1)$$

Π_t denotes the efficiency at time t, $Initial_t$ is a dummy variable indicating the first trading day of a new monetary horizon[7], and ε_t is assumed to be a random iid $N(0,\sigma^2)$ variable. Table 2 reports the estimation of the model parameters for each of the seven treatments.

Table 2: Parametric Time Series Models by Treatment

Estimated Model: $\Pi_t = \alpha + \beta\Pi_{t-1} + \delta Initial_t + \varepsilon_t$							
Treatment	Backed Money Long Horizon	Backed Money Short Horizon	Fiat Money Long Horizon	Fiat Money Short Horizon	Active Government Long Horizon	Active Government Short Horizon	Exogenous Money Growth
α	1.1067* [0.001]	0.7422* [0.013]	0.4884* [0.001]	0.2700* [0.005]	0.0928 [0.310]	0.0781 [0.416]	0.2307* [0.014]
β	-0.1488 [0.601]	0.2410 [0.391]	0.3871* [0.023]	0.4636* [0.001]	0.6912* [0.000]	0.6502* [0.000]	0.6288* [0.000]
δ	-0.0032 [0.918]	-0.0224 [0.184]	0.0264 [0.571]	0.1331* [0.000]	0.1471 [0.101]	0.0689 [0.278]	0.0189 [0.708]
Number Of Observations	16	16	34	40	34	24	36
$\alpha/(1-\beta)$ Estimated Point of Convergence	0.9633	0.9779	0.7968	0.5034	0.3007	0.2232	0.6215
p-value for Modified Breusch Godfrey Test (Ho: no autocorrelation in residuals)	[0.761]	[0.898]	[0.380]	[0.905]	[0.416]	[0.390]	[0.357]

Π_t denotes private efficiency at time t and $Initial_t$ is a dummy indicating a regime's initial period. Numbers in brackets are the p-values associated with a test of the null hypothesis. The null hypothesis for the parameter estimates of α, β, and δ is that the parameter is zero versus the two-sided alternative. * indicates a rejection of the null at the 5% significance level.

Also reported in Table 2 are the p-values associated the modified Breusch Godfrey test[8] which asks if the coefficient on e_{t-1} is different from zero in a linear projection of e_t on Π_{t-}

[7] The decision to include an initialization dummy is based on public goods experiments with voluntary contribution mechanisms that routinely find individual contributions increase when a new public good is introduced even as contributions decrease as the same public good is repeated. See Marwell and Ames (1985) and Isaac and Walker (1998).

$_1$, S_t, e_{t-1}, and a constant term, where e_t is the time t residual from the estimated model. Based on this test, the hypothesis that there is no autocorrelation in the residuals cannot be rejected for any of the treatments.

The estimate point of the convergence for a particular series is $\alpha/(1-\beta)$.[9] To determine the tendencies of each treatment, two separate hypothesis tests are conducted. One hypothesis tested is that the economy was converging to zero. This is equivalent to an α of 0 in equation (1). Based on the p-values associated with α reported in Table 2, only in the two active government sessions can the null hypothesis that $\alpha=0$ not be rejected at the 5% significance level.

The second hypothesis tested is that private economy was converging to full efficiency or equivalently that $\alpha/(1-\beta) =1$. This point of convergence is well defined as the Modified Breusch Pagan test rejects that $\beta \neq 1$. Using a likelihood ratio test, the hypothesis of convergence to 100% private efficiency cannot be rejected at the 1% significance level for either backed money treatment. For the remaining treatments the hypothesis is rejected for all standard significance levels. These results are reported in Table 3.

This analysis demonstrates that fiat money in a long horizon regime with no growth in the money supply and both long and short horizon regimes with backed money provide stable mediums of exchange in an economy converging to a high level of efficiency, $\approx$ 80%, $\approx$ 100%, and $\approx$ 100% respectively. Short horizon fiat money regimes with no money growth and long horizon exogenous money growth regimes can sustain

[8] The commonly employed Durbin-Watson test for autocorrelation has a potential bias towards finding no autocorrelation when lagged values of the dependent variable are included as an independent variable. See Greene (1997).

trade, thereby allowing more than 50% of the maximum surplus to be attained. In contrast, economies with an active government collapse, converging to zero efficiency.

Table 3: Hypothesis Tests for Convergence to Full Private Efficiency

Treatment	Backed Money Long Horizon	Backed Money Short Horizon	Fiat Money Long Horizon	Fiat Money Short Horizon	Active Government Long Horizon	Active Government Short Horizon	Exogenous Money Growth
Ho: Series Converges to Full Efficiency, $\alpha/(1-\beta) = 1$ Restricted Model: $\Pi_t - 1 = \beta(\Pi_{t-1} - 1) + \delta Initial_t + \varepsilon_t$							
Unrestricted Estimate of $\alpha/(1-\beta)$	0.9633	0.9779	0.7968	0.5034	0.3007	0.2232	0.6215
Sum of Squares Unrestricted Model	0.029	0.012	0.306	0.430	1.242	0.470	0.396
Sum of Squares Restricted Model	0.043	0.013	0.419	0.866	1.642	0.700	0.504
Likelihood Ratio Test Statistic	6.066	1.212	10.719*	27.992*	10.056*	9.560*	8.740*
P-value	0.014	0.271	0.001	0.000	0.002	0.002	0.003

Π_t denotes private efficiency at time t and $Initial_t$ is a dummy indicating a regime's initial period. The test statistic has a $\chi^2(1)$ distribution.
* indicates a rejection of the null at the 1% significance level.

The above parametric analysis examines the time path of private efficiency within a given treatment. To compare the relative impact of various treatments a linear mixed effects model is employed. The linear mixed effects model treats the difference between two treatments as being a fixed effect but allows each session to differ by a random effect. The following functional form of a linear mixed effects model was estimated where the error terms are assumed to have an AR(1) process within each session:

[9] Due to lagged dependent variables in the set of regressors the estimates are biased, however, the technique does generate consistent estimates.

$$\Pi_{j,t} = \alpha + \delta_j + \beta_1\zeta(\text{Long}_j) + \beta_2\zeta(\text{Gov}_j) + \beta_3\zeta(\text{Gov} \cap \text{Long}_j) + \beta_4\zeta(\text{Growth}_j) + \beta_5\zeta(\text{Initial}_{j,t}) + \beta_6\zeta(\text{Initial} \cap \text{Gov}_{j,t}) + \beta_7\zeta(\text{Initial} \cap \text{Long}_{j,t}) + \beta_8\zeta(\text{Initial} \cap Gov \cap \text{Long}_{j,t}) + \beta_9\zeta(\text{Initial} \cap \text{Growth}) + \varepsilon_{j,t} \quad (2)$$

Again, $\Pi_{j,t}$ is the private efficiency in session j at time t. ζ denotes an indicator function that is one if the term in parentheses is true for the j,t observation. The variables Long, Gov, and Growth are dummies referring to sessions with a long horizon, an active government, and exogenous money growth respectively, while X∩Y denotes a session with both properties X and Y. Initial refers to period t being the trading day in which money was initialized. Note that the indicator function for (Growth ∩ Long) is omitted as no sessions were conducted with both exogenous money growth and a short horizon. Table 4 reports the values of the estimated model.

The estimation of the mixed effects model shows that across treatments there is a positive surge in efficiency in the trading day in which money is reinitialized. However, this gain does not depend on the specific monetary regime that is in place as is evidenced by the high p-values associated with β_6, β_7, β_8, and β_9. This finding indicates a robust willingness of individuals to attempt trade. Of marginal significance are the duration of the economy (p-value of 0.1113 in a two-tailed test), the presence of an active government (p-value of 0.1365 in a one-tailed test), and the exogenous money growth (p-value of 0.1169 in a one-tailed test). Further, the interaction of an active government and a long horizon lowers efficiency at a marginally significant level (p-value of 0.1533 in a one-tailed test). Taken together these results lead to the same conclusions as the treatment specific analysis presented above. Specifically, the fiat money long horizon treatment achieves the highest level of efficiency of any non-backed money regime.

Short horizon fiat money and exogenous money growth economies attain approximately equal levels of efficiency at a level far greater than that achieved when an active government is present.

Table 4: Mixed Effects Model Estimation for Non-Backed Money Sessions

Estimated Model: $\Pi_{j,t}=\alpha+\beta_1(\text{Long})+\beta_2(\text{Gov})+\beta_3(\text{Gov}\cap\text{Long})+\beta_4(\text{Growth})+\beta_5(\text{Initial})+\beta_6(\text{Initial}\cap\text{Gov})+\beta_7(\text{Initial}\cap\text{Long})+\beta_8(\text{Initial}\cap\text{Gov}\cap\text{Long})+\beta_9(\text{Initial}\cap\text{Growth})+\varepsilon_{j,t}$

$\varepsilon_{j,t}=\rho\varepsilon_{j,t}+u_t$ where $u_t \sim$ iid $N(0,\sigma^2)$

Parameter (Independent Variable)	Coefficient Estimate	Standard Error	Degrees of Freedom	T statistic	p-value
α (Constant)	0.6506	0.072	165	9.0412	<0.0001
β_1 (Long)	0.1821	0.104	10	1.7464	0.1113
β_2 (Gov)	-0.1284	0.111	10	-1.6011	0.2730
β_3 (Gov $\cap$ Long)	-0.1650	0.153	10	-1.0774	0.3066
β_4 (Growth)	-0.1341	0.106	10	-1.2675	0.2337
β_5 (Initial)	0.0795	0.027	165	2.9451	0.0037
β_6 (Initial $\cap$ Gov)	-0.0564	0.044	165	-1.2794	0.2026
β_7 (Initial $\cap$ Long)	-0.0470	0.056	165	-0.8401	0.4021
β_8 (Initial $\cap$ Gov $\cap$ Long)	0.1097	0.082	165	1.335	0.1837
β_9 (Initial $\cap$ Growth)	-0.0475	0.069	165	-0.684	0.4946

Estimate of AR(1) Process in the Error Structure: $e_{j,t}=.73e_{j,t-1}+u_t$

$\Pi_{j,t}$ denotes the private efficiency in period t of session j. Long, Gov, and Growth denote treatments that have a long horizon, an active government, and exogenous money growth respectively. Initial denotes a period in which money was initialized. a $\cap$ b is a dummy variable that is one if a=1 and b=1. Reported p-values are associated with testing that the coefficient is zero against the two-sided alternative.

Anecdotal evidence also exists that supports the claim that an active government leads to extremely low private efficiency. The smaller number of trading days in the active government sessions was endogenously determined. All experimental sessions were designed to last twenty trading periods. Some sessions were forced to end before all

periods occurred due to time constraints; however, in the active government sessions the shortened time was the result of subject upheaval. In one extreme case a subject caused a scene demanding to leave the experiment after repeated days of little trade volume and hence low profits. This subject's behavior was anticipated by Keynes (1920) who said that "There is no subtler, no surer means of overturning the existing basis of society than to debauch the currency."

Conclusions

Individuals are able to coordinate and achieve a high proportion of the gains from trade using fiat money as a medium of exchange in decentralized finite horizon markets. The price level, trade volume, and market efficiency are comparable to those of economies using backed money. While repeated experience with the termination of a fiat money regime, such as in the short horizon, results in lower levels of efficiency and moderate inflation, the economy remains active in comparison to the no trade prediction of the standard economic model.

An active government results in a hyperinflation. This collapse in the real economy is due to the corruption of the price discovery process and not to the associated increasing money supply. An active government distorts the pricing mechanism to the point where individuals are unable to complete real trades, one good for another. The result is autarky. However, the nominal price increases associated with hyperinflations are due to the increased liquidity in the economy.

These findings are consistent with the rational expectations hypothesis. Agents agree to transact in an environment where mutual gains from trade can be reaped, thereby justifying the fiat money's acceptance. Individuals adjust nominal prices to reflect the

supply of money in the economy, while real prices remain unaffected by such pure monetary phenomena. As the public sector begins to crowd out private consumption, individuals update their valuation of the money, ultimately causing the economy to unravel.

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