Informed and Uninformed Investors

in an Experimental Ponzi Scheme

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1. Introduction

In 1997, the Albanian economy suddenly collapsed after four years of rapid growth following decades of communist dictatorship and central planning. The main reason for the collapse was the unravelling of a series of what was commonly referred to as ‘pyramid schemes’. A large number of Albanians invested and lost their life savings in funds that went bankrupt. This led to a political and economic chaos that is still paralysing the country today. To get a better understanding of individual behaviour in such schemes, this paper studies them in a structured, laboratory environment. To do so, we have to consider carefully what kind of schemes were actually used. The term ‘pyramid’ is used as a general phrase that actually covers a variety of schemes.

A classic pyramid is a form of fraud, which operates on the assumption that some individuals (at the ‘top’) will earn money from the investments of others. As time progresses, more and more people are needed to support those in the upper levels. These pyramid schemes can be either legitimate or illegitimate (Simmons, 1996). The legitimate pyramid structure is often called a multilevel marketing (MLM) organisation. Its primary purpose is to sell a product. There are many successful MLMs, which sell encyclopaedias, soaps and cosmetics, among other items. The return or earnings to the upper levels of the pyramid are from both the sale of the product and the recruiting of new salespersons. The return is generated from both one's own commission sales and also the commissions on sales of those one recruits.

In an illegitimate pyramid, the primary return to the upper level individuals is from recruiting of new participants. In this structure, the return is derived from investments by others and not from commissions on the sale of any product. They offer investment returns which sound better than what is offered in the marketplace. The investors are encouraged to reinvest the profits rather than take a payoff. The illegitimate pyramid is often referred to as a Ponzi scheme, named after Charles Ponzi, an immigrant to Boston in 1919. In general terms, *Ponzi schemes are games where individuals or companies pay out funds to some parties by borrowing funds from others*. Therefore, illegal pyramids are one kind of Ponzi scheme.

The distinguishing feature of a Ponzi-type pyramid is that old victims are paid back with funds received from new victims. As long as the pyramid continues to grow, the investors are not usually aware that their money has been misappropriated. Most of these schemes unravel when new

‘ investors’ can no longer be located. Generally, illegal pyramid schemes collapse of their own weight. The schemes often are not reported and, therefore, not prosecuted because individuals are embarrassed to admit that a con artist fleeced them. The illegitimate recruiter can be anyone: a friend, relative, neighbour, work peer, church member, or someone not known.

Ponzi schemes are more general than only the pyramid type, however. All share some of the characteristics of pyramid schemes but also have some different dynamics[1]. The kind of Ponzi scheme that was observed in Albania, is characterized by the promotion of what starts out to be, or appears to be, a real investment opportunity. From here onward, we will use the term ‘ Ponzi scheme’ to refer to this type and ‘ pyramid scheme’ to refer to the more classic form discussed above.

A Ponzi scheme often involves the development of a valuable resource such as oil, gas, minerals or real estate. And what is being promoted often actually exists. The promoter does own a mine, or does own investment property. Where the resource actually exists, the promoter has grossly overvalues its worth. Other times, the asset or resource, which is the basis for the investment opportunity, is a figment of the promoter's imagination. In either scenario, the promoter convinces investors that the asset can be further developed with more capital, and the promoter will share the profits with the investors.

In these (non-pyramid) Ponzi schemes, substantial dividends are paid out to the investors early on. The representation is that these dividends are ‘ profits’ coming from the successful development of the investment assets. What is actually happening is that the promoter is merely returning a portion of the investors' money to them. These early and substantial dividends produce two results. First, the early investors increase their share of the operation, and additional investors are attracted to the scheme. The process of paying dividends continues and more investors come forward until the fraud is uncovered or the promoter absconds with the investment proceeds.

Not all Ponzi schemes start out as frauds. Sometimes a promoter in good faith really believes the asset will prove profitable. Investment money comes in, but the returns are disappointing. To avoid loss of investor confidence lies are circulated and dividends paid. More money comes in and the possibility of millions of dollars of losses occurs.

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[1] Gerald P. Nehra in "http:/mimstartup.com/articles/ponzi.htm

There are several distinctions between these Ponzi schemes and pyramid schemes. First, a pyramid scheme involves a person making an investment for the right to receive compensation for finding and introducing other participants into the scheme. There is a clear understanding among the participants that the success of the opportunity is dependent upon attracting additional participants. This is different from the expectations of the Ponzi scheme participant who believes the investment is dependent upon the successful development of a productive asset such as a mine or real estate complex.

Second, pyramids must fail because, by their nature, they depend upon endless exponential growth to succeed. Ponzi schemes must fail because the underlying asset upon which the investment was based either never existed, or was grossly overvalued. Pyramid schemes require active participants who bring in more participants. Ponzi schemes can flourish even with passive investors without any responsibility to promote the opportunity.

Finally, pyramid scheme participants ‘go for gold’ by attracting others to the scheme. Ponzi scheme participants ‘go for gold’ by increasing their investment and hopefully their share of the profits from the successful development of the productive asset.

The important thing that both schemes have in common is that to survive, they need to use invested funds to pay other investors. When there is insufficient money left (e.g., because investors start to withdraw), they collapse.

As mentioned above, the schemes in Albania are organised as Ponzi schemes. The earning of investors do not depend on whether or not they bring in other investors. Earnings are determined by the amount of money the investor invests and level of interest rates. The driving force for the scheme to exist is that the amount of money invested must be higher than the amount of money needed to be paid out.

In these Ponzi schemes there are typically two type of investors participating: informed and uninformed (Sadiraj and van Wijnbergen, 1997). Informed investors are governmental influential people who try to maximise their earnings for the time they have influence people and uninformed investors are the ‘common people’. The informed investors control the main sources of information dissemination, the media. They give positive information about the existence of these schemes giving the impression to common people that government is behind it and it is a secure investment with high returns. The advantage for informed investors is that they get out of the scheme on time, which they can calculate through the total excess they have to information. The informed investors are the ones who make the first move.

It is very difficult to obtain field data on the pyramid schemes. Apart from the fact that many of these schemes are illegal and therefore do not have public records, the records that are available will generally have very noisy data. They have typically flourished in countries were reliable data on variables like inflation or interest rates offered by different institutions are difficult to find.

The aim of this paper is to study these schemes in a controlled laboratory setting. We will study the behavior and decisions of individuals in an experimental investment project with the main characteristics of Ponzi schemes. These include an unrealistically high interest rate, the possibility of keeping the scheme alive by using invested funds to pay out interest and an increasing probability of bankruptcy as time passes by**.** In addition, as in Sadiraj and van Wijnbergen (1997) we distinguish informed from uninformed investors. This is explained in the following section. Finally, our controlled pyramid scheme allows for a real return to investments. This return is insufficient to cover the interest paid, however. Only the informed investors know the real return. For simplicity, we assume that this return takes the form of an initial sum in the investment fund that is not increased in the time the scheme exists. This sum can be used to pay interest without eating into the money invested by the subjects. This can only be done for a limited number of periods, however. Once the entire initial sum is depleted, interest payments are at the cost of money invested by the participants. In studying behavior in these schemes, we are mainly interested in comparative statics. In particular, we will consider the effect of a raise in the interest rate paid and a decrease in the relative number of uninformed investors.

In the following section, the game used to study pyramid schemes is presented in more detail. Section 3 provides a theoretical solution to this game. Experimental procedures and design are presented in section 4 and the results are discussed in Section 5. Section 6 discussed implications and concludes.

2. The Ponzi-Game

In the game used to describe Ponzi schemes, investors have to decide whether or not to invest a fixed sum Y (equal across investors) in an investment fund (IF). Investors j are either *informed* ($j \in I$) or uninformed ($j \in U$). We use the notation ' I' (' U') both to denote the set of informed (uninformed) investors and for the number of informed (uninformed) investors. The total number of (potential) investors is then given by N=I+U.

Before individual investment decisions are made (i.e., at time t = 0) there is an initial investment χ in IF, reflecting real returns. We assume that nature draws χ from a uniform distribution, i.e. $\chi \in [p, q]$ where q>p>0. Next, informed investors are told the realization of χ. They may either invest Y in IF or invest nothing. Hence, their strategy space in any period is {0,Y}.[2] As long as bankruptcy does not occur (see below), the game moves on to the uninformed.

The uninformed players do not know the exact value of χ but they know that χ is a stochastic variable with a uniform distribution. After the informed made their decision in a period, and if bankruptcy did not occur, the uninformed choose a strategy from {0,Y}. Again, if bankruptcy does not occur (see below), a return rdY is paid to every $j \in I,U$ where d is a dummy denoting whether or not j invested in IF. Interest payments are paid out of the funds in IF and therefore diminish the amount of money available for the future. Hence, if the amount of interest payments previously paid were larger than χ, the amount remaining in the scheme would be insufficient to pay back the investments of all investors, if they simultaneously wished to withdraw. This makes the game of a Ponzi scheme type.

There is a restriction in the strategies allowed. If an investor has previously withdrawn money (i.e., she has invested zero after previously investing Y), she is not allowed to invest again. This implies that withdrawal is final.

In any round, the informed have the option of withdrawing their funds before the uninformed make their decision. The decision by the informed is not made public until the end of the period. At that point, the aggregate investment decisions of the informed and the uninformed are made public and a new round is started. Hence, when the informed make their decision, they know what the (aggregate) most recent decision of the uninformed is (and, knowing the realization of χ, they can calculate the exact amount of funds in the scheme. On the other hand, the uninformed know neither the realization of χ, nor the most recent investment decision of the informed when they decide what to do.

[2]In fact, the decision to be made if a subject in our experiments previously invested is whether or not to withdraw this investment. Formulating it in the way we have done allows us to assume a constant (and symmetric) strategy space.

In every round, there are two points in time where bankruptcy may occur. First, when the informed make their investment decision, some might want to withdraw their investment. If the amount of money they wish to withdraw is less than the funds available in IF, the withdrawals are realized. If not, bankruptcy occurs. Second, at the end of the round, money is needed to pay for the withdrawals of the uninformed participants plus all interest payments. If there is enough money available in IF, these are realized. If not, bankruptcy occurs. In case of bankruptcy, the funds remaining in IF are equally split across all remaining investors.

Denote the amount of money available in IF in period t by x_t and let d^t_i be a dummy equal to 1(0) if i invested (did not invest) in period t. The following overview summarizes the structure of the game.

Period 0 — nature invests χ in X; $x_0=\chi$.

if $j \in$ I, j is informed of the value of χ.

Period 1 — a) all $j \in$ I choose a strategy from {0,Y}

b) all $j \in$ U choose a strategy from {0,Y}

c) total investment is $\chi + \Sigma_{j\in I,U} d^1_j Y$

d) Payoffs to $j \in$ I,U is $r d^t_j Y$

e) investment left in $X \equiv x_1 = \chi + (1-r)\, \Sigma_{j\in I,U} d^1_j Y$

Period t — a) all $j \in$ I,U are informed of $\Sigma_{j\in I} d^{t-1}_j$ and $\Sigma_{j\in U} d^{t-1}_j$

b) all $j \in$ I choose a strategy from {0,Y}, unless they have previously withdrawn

c) if the decisions of $j \in$ I were to be implemented , the amount invested would be: $x_{ta} \equiv \chi + \Sigma_{j\in U} d^{t-1}_j Y + \Sigma_{j\in I} d^t_j Y - r\Sigma^{T-1}_{\tau=1} \Sigma_{j\in I,U} d^\tau_j Y$. One must then check whether x_{Ta} is sufficient to cover the withdrawals in period t by $j \in$ I. Because we define strategies as a decision from {0,Y}, a withdrawal is an investment of 0 following a previous investment of Y. In fact, a bankruptcy occurs when $x_{ta} < 0$.

d) all $j \in$ U choose a strategy from {0,Y}, unless they have previously withdrawn.

e) This would make current investment $x_{tb} \equiv \chi + \Sigma_{j\in I,U}\, d^t_j Y - r\Sigma^{T-1}_{\tau=1}\Sigma_{j\in I,U} d^{\tau}_j Y$. Bankruptcy occurs when x_{tb} is insufficient to cover interest payments in period t, for which one needs $r\Sigma_{j\in I,U}\, d^t_j Y$.

3. Theoretical Analysis

Before turning to game theoretic aspects of this game, consider efficiency. Note that the initial investment χ (the 'real return') can only be realized (earned by the subjects) if sufficient investments are made. Any other (interest) earnings are effectively a redistribution of income. Therefore, any outcome where there are sufficient investments to have χ paid out as interest is efficient.

In this multi-stage game, a strategy is a complete plan of action. First, consider the case where every player invests Y in every period. As a consequence, bankruptcy occurs and the remaining funds are distributed evenly. It is easy to see that each investor earns $Y + \chi/N$ in this case. In general, this is not a Nash equilibrium, however. Assume that bankruptcy occurs in period T. Hence, T is implicitly determined by the conditions that

(1) the available funds were sufficient for interest payments in T-1, implying $\chi + NY > (T-1)rYN$;

(2) the available funds are insufficient for interest payments in T, implying $\chi + NY < TrYN$, or $\chi < TrYN - NY$.

Next consider an investor that withdraws her investment in T-1. She earns $(T-2)rY + Y$. Comparing this to the bankruptcy payoff, we find that withdrawal in T-1 is profitable when

$$(T-2)rY + Y > Y + \chi/N, \text{ or } \chi < N(T-2)rY = TNrY - 2NrY.$$

Given the second condition for bankruptcy in T, a sufficient condition for profitable withdrawal in T-1 is $NY > 2NrY$, or $r < 0.5$. In that case, the situation where everyone stays in until bankruptcy is not a Nash equilibrium.

Similarly, no outcome can be a Nash equilibrium if all investments are withdrawn and more than rY is left in IF (because a single investor can increase her earnings by investing one more period). For example, no investments in IF at all is not an equilibrium.

Next, consider quasi-symmetric strategies, i.e., symmetric strategies within the group of informed traders and symmetric strategies within the group of uninformed traders. A first thing to note is that in equilibrium, an investor will not postpone investing until a period t>1. In this case, she can unilaterally increase earnings by investing in periods 1..t-1 and, if necessary, moving the period of withdrawal forward. Therefore, we only consider strategies where subjects invest in period 1 and withdraw in period t. If t=1 this implies not investing at all. A strategy is then characterised by the period in which the investment is withdrawn.

Therefore, assume that uninformed investors all follow the strategy that they withdraw in period t*, unless they observe the informed withdrawing in t<t*-1. In the latter case, the informed withdraw in period t.[3] We will (A) first determine the best reply of the informed. Next, (B) we will argue that this best reply does not affect the t* chosen by the uninformed. Then (C) we will discuss the incentives for individual investors to deviate from the optimal quasi-symmetric strategies. Finally, (D) we determine the optimal t*.

*(A) The best reply to t**

Let R_t denote the total amount of money paid as interest in the periods 1,..,t-1. Thus,

$$R_t = r\Sigma^{T-1}{}_{\tau=1}\Sigma_{j\in I,U}d^{\tau}{}_{j}Y.$$

Also, let t_χ be the number of periods that interest can be paid to all N investors, given the realized value of χ. Hence, t_χ is such that $R_{t\chi}<\chi$ and $R_{t\chi+1}>\chi$. Next, if t_χ > t*-1, let t** > t* be the lowest number of periods for which χ is insufficient to pay interest if all N investors receive interest for t*-1 periods (R_{t*}=(t*-1)NrY) and only the I informed investors receive interest thereafter. In this case, the uninformed leave the scheme before χ has been paid out completely as interest and the informed can stay in longer (until period t**-1) without risk. Thus, if t_χ > t*-1, t** is such that:

$$\chi - R_{t*} - (t^{**}-t^*)rIY > 0 \text{ and } \chi - R_{t*} - (t^{**}+1-t^*)rIY < 0.$$

The final thing to consider before describing the best reply of the informed to the uninformed strategy t* is the fact whether interest payments in excess of χ are being paid out of the investments of the uninformed or of the informed. We will choose parameters in a way that insures that χ plus the investments by the uninformed are sufficient to pay interest to all investors until t*. We will call this the Ponzi-condition. If it is not fulfilled, the informed are in fact playing a game of chicken amongst themselves that is not relevant for the Ponzi scheme.

Now, assuming that the Ponzi condition is fulfilled, if the uninformed play the strategy t*, the best reply by the informed is to play the strategy:

withdraw in	t*	if $t_\chi \leq t^*-1$
	t**	if $t_\chi > t^*-1$.

The intuition underlying this strategy is that the informed will withdraw at the last chance before the uninformed do, if the latter are 'overestimating' the amount of money available. In this case, the informed will draw interest from the investments by the uninformed. If the uninformed are underestimating the amount available, the informed will stay in until χ is (almost) depleted.

It is easy to see that this is a best reply to t* if all informed are forced to use the same strategy. If $t_\chi \leq t^*-1$ no informed investor has a reason to withdraw at a different time than t*. If $t_\chi > t^*-1$, all informed investors will stay in as long as the amount of money left in excess of investments is enough to pay interest to all. If the amount remaining is enough to pay interest to a subset of the informed investors, a game of chicken occurs between the informed players (similar to the situation described in Sadiraj and van Wijnbergen, 1997). We will not discuss this 'subgame' in the present analysis.

[3]If the uninformed observe the informed withdrawing, this indicates that the amount of money left from χ is insufficient to pay interest. We will argue below that, in equilibrium, the informed will not

*(B) Effect on t**

Next, we consider whether this best reply will affect the t* chosen by the uninformed. This is not the case. The structure of the strategy by the informed is such, that an uninformed cannot derive any information about the value of χ from it. Therefore, the uninformed will not update their beliefs about χ' s value and stick to their originally determined t*.

*(C) Individual deviation from t**

Are there reasons for individual uninformed investors to deviate from the quasi-symmetric t*? As with the informed, the only reason for individual deviation would be that there is enough money (expected) for interest payments to some uninformed but not enough for all. Again, the consequence is a game of chicken between the uninformed, which we will not focus on.

*(D) Determining t**

Therefore, we now determine the optimal t*. To do so, we determine the withdrawal period that maximises the expected return for the uninformed investor. Recall that χ is drawn from a uniform distribution on the domain [p, q]. Let t_p (t_q) be the number of periods that all N participants can receive interest payments, if χ=p (χ=q).

First note that there are t_q-t_p+1 discrete periods in the interval $[t_p,t_q]$. The probability that $\chi \in [p,q]$ is large enough to pay interests to all I+U participants for exactly t_p+n periods, $0 \leq n \leq t_q-t_p$, is equal to $1/(t_q-t_p+1)$. If the uninformed stay in for t_p+n periods, the probability that $t_\chi \geq t_p+n$ (hence, the uninformed do not lose money to the informed) is equal to $(t_q - (t_p+n) +1)/(t_q-t_p+1)$. The probability that any of the outcomes that $t_\chi = t_p, t_p+1 \ldots t_p+n-1$ occurs is $1/(t_q-t_p+1)$. Note that the probabilities over all t_χ ($=t_p..t_q$) sum up to 1.

Define $Pr \equiv 1/(t_q-t_p+1)$ and denote money earnings by π. Recalling that we are still assuming that the Ponzi condition is fulfilled, the expected payoff from staying in for $t^*=t_p+n$ periods ($n\in\{0,1,\ldots,t_q-t_p\}$ is given by:

$$E(t_p+n)= P(t_\chi \geq t_p+n)\, \pi(t_p+n \mid t_\chi \geq t_p+n) + P(t_\chi<t_p+n)\pi(t_p+n \mid t_\chi< t_p+n)$$

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withdraw in any t<t* for certain parameters.

$$= \{(rY\ (t_p+n)+Y)\ (t_q-(t_p+n)+1)\}\ Pr + \sum_{i=tp}^{tp+n-1} (\{UY-(t_p+n - i)rIY\}/U + riY)\ Pr$$

$$= \{(rY\ (t_p+n)+Y)\ (t_q-(t_p+n)+1)\}\ Pr + \sum_{i=tp}^{tp+n-1} [riY(1+I/U) -(t_p+n)rIY/U+Y]Pr$$

The first part of this expression gives the expected (net) interest earnings in case when $t_\chi > t^* = t_p+n$. The summation gives the expected net interest earnings for $t_\chi < t^*$. In this case, bankruptcy will occur when the uninformed try to withdraw in t*. The net earnings are determined by what the uninformed player gets before bankruptcy minus interests that are paid to the informed from the investments of the uninformed.

Because q and rY are independent of n, maximisation (over n) of E is equivalent to maximisation of $E' \equiv E/(PrY)$ over n. Rewriting gives:

$$E' = (r\ (t_p + n) +1)(t_q - (t_p + n) + 1) + (r(1 + I/U) \sum_{i=tp}^{tp+n-1} i\ ) - (t_p + n)\ r\ n\ I/U +n$$

$$= (r\ (t_p + n) +1)(t_q - (t_p + n) + 1) + (r(1 + I/U)\ (nt_p+n(n-1)/2)- (t_p\, n+ n^2)\ r\ I/U+n$$

Taking the derivative:[4]

$$dE'/dn = 0 = r(t_q- 2t_p +1)-1 -2nr +r(1-I/U)n - (r/U)(U/2+I/2\ Ut_p) +1$$

Note that the second derivative is equal to -r(1+I/U), i.e. negative. So, we are dealing with a maximum. Hence, $n =[t_q - t_p + (1-I/U)/2]\ U/(U+I)$ and $t^* = t_p + n = t_q + I/N\ t_p + (U-I)/2N$. Hence, for given parameters, we can easily calculate the quasi-symmetric equilibrium.

4. Procedures and Parameters

The experiments were run at the CREED laboratory of the University of Amsterdam in May-July 1998. Subjects were recruited from the undergraduate population. When they arrived at the

[4] Formally, we cannot take the derivative to n, because n is discrete, of course. The function is such, that we can optimise for continuous n, however. If the optimum is for non-integer n, we need to

laboratory, they were informed that they would participate in two experiments, one of which was on the Ponzi schemes reported here. In total, XXX subjects participated. This experiment lasted about 1 hour. On average, participants earned YYY guilder.
[decisions, instructions, etc.]

In all of our experiments, we chose N=16, Y=250 Dutch cents[5], p=1600 Dutch cents, q=4800 Dutch cents. The parameters we varied in our experiments are the interest rate r, and the relative number of informed, I/U. The values chosen were r=0.1 versus r=0.2 and I=1/U=15 versus I=8/U=8. For these numbers it can be shown that the Ponzi condition is fulfilled. We shall refer to the high (low) interest sessions as Hi (Lo) and to the sessions with 1 (8) informed subject(s) as 1I (8I). Because we ran a full between subject design, we have the following four kind of sessions: Hi1I; Hi8I; Lo1I; Lo8I. We ran each of these sessions ZZZ times.

The values of t_p and t_q depend on r. With the parameters chosen, we have $t_p=2$, $t_q=6$ for Hi1I and Hi8I and $t_p=4$, $t_q=12$ for Lo1I and Lo8I. In Hi1I and Hi8I, the value of χ was chosen from the set {1600, 2400, 3200, 4000, 4800}. In Lo1I and Lo8I the set was {1600, 2000, 2400, 2800, 3200, 3600, 4000, 4400, 4800}. The reason why the set is larger with the low interest rate, is that we chose the values in a way that interest could be paid from χ to all subjects for exactly an integer number of periods, if all invested.

Because the Ponzi condition is fulfilled, we can use the calculations of the previous section to determine the quasi-symmetric equilibrium strategy t*. These are given in the following table.

I	1	8
r = 0.1	12	8
r = 0.2	6	4

check which of the adjacent integers is optimal. If the optimum is ‘ out of bounds’ , the corresponding corner solution is the optimum.

[5] At the time of the experiments, 250 cents = $1.25.

Hence, in this equilibrium, all subjects will keep their money invested in the fund until t_q in Hi1I (t_q=6) and Lo1I (t_q=12). In Hi8I and Lo8I the uninformed will withdraw halfway between t_p and t_q and the informed will do the same for low draws of χ but stay in longer for high draws.

5. Experimental Results

To date, each of the four treatments (Lo1I, Lo8I, Hi1I and Hi8I) has been run once. In all rounds of every session, there a bankruptcy occurred: in the late periods of every round χ was completely depleted and money invested by players was used to pay out interest.

Figures 1-4 show the average participation rates for informed and uninformed investors across periods in the various sessions.

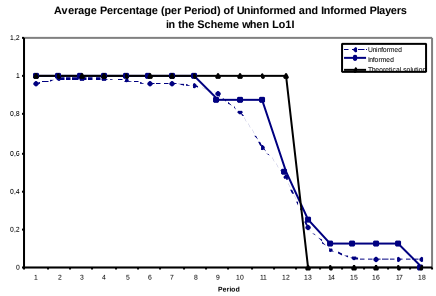

Figure 1

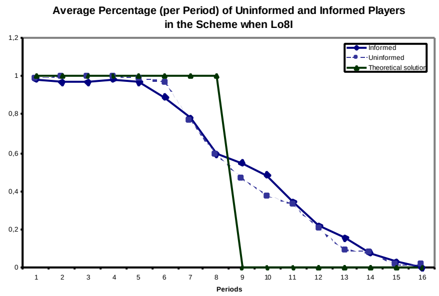

Figure 2

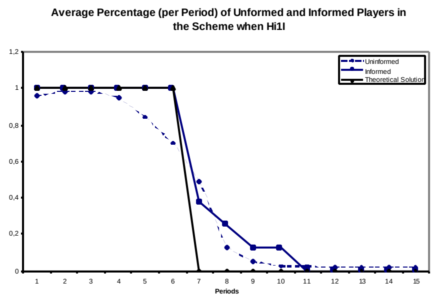

Figure 3

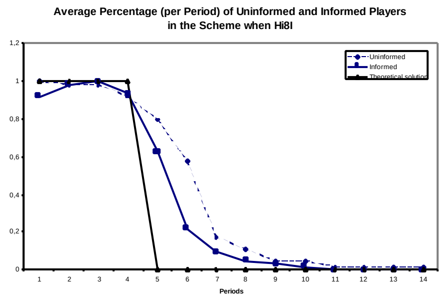

Figure 4

In these figures, the bold (dashed) lines represent the average percentage of informed (uninformed) players participating in the scheme in a given period. The thin solid line represents the participation rate in the quasi-symmetric Nash equilibrium (which is to participate until t*; where t* depends on the treatment). A first observation from these graphs is that participation decreases as time proceeds.

Furthermore, when comparing 1I (figures 1 and 3) with 8I (figures 2 and 4), it appears that participation in periods beyond t* is higher when there are more informed. An explanation for this phenomenon may be the following. First, note that in some sense, periods beyond t* are more ‘ risky’ for the uninformed. Apparently. when there are more informed players the uninformed tend to take more risks and follow the moves of the informed. In turn, this allows the informed players to adjust their strategy and stay in the scheme longer.

Comparing the participation of uninformed and informed investors, the results are slightly mixed. In 8I participation by the informed is a bit lower on average than by the uninformed for Lo (figure 2), especially in later periods. However, the uninformed participate at a clearly higher rate in Hi (figure 4). On the other hand, the informed seem to participate at a higher rate than the uninformed in all periods of both 1I treatments.

Estimation Results

To obtain a better understanding of the experimental results, we use a discrete hazard model to study the decision to withdraw money from the scheme. This model describes the probability of leaving the scheme in period t conditional on participating in t-1. This probability is called the hazard rate. It is a function of the period and of a set of covariates (which may or may not be time dependent). Details can be found in Lancaster (1990).

To estimate this model, we apply a parameterization using the exponetial distribution. The covariates we use can be split in time dependent, X_t, and fixed, Z. Z includes binary variables indicating the player type (informed or uninformed), the interest rate and the ratio of informed to uninformed players. In addition, we add dummy variables indicating the round number (1..8) to Z. X_t includes exogenous variables like the period number and the value of χ drawn. In addition, for the uninformed only, it includes an endogenous variable describing the number of informed players withdrawing their funds in the previous round. The hazard rate θ is then given by:

$$\theta = 1- \exp(-\exp(\gamma_t+\alpha X_t + \beta'Z).$$

When estimating α, β, and γ, we correct for the fact that we have censored data (i.e., subjects cannot participate after bankruptcy). The estimation results are presented in table 1

Table 1.

Mean log-likelihood	-6,52062	
Parameters	Estimates	Standard errors
G2-Second Period	-6,0714	0,5897
G3- Third Period	-6,7688	0,7732
G4- …	-4,909	0,4194
G5	-3,6552	0,3492
G6	-2,9258	0,3393
G7	-2,25	0,3144
G8	-2,3152	0,337
G9	-2,3149	0,3789
G10	-1,8666	0,3635
G11	-1,1919	0,3481
G12	-0,5893	0,3337
G13	-0,2985	0,3686
G14	-0,1125	0,4335
G15	0,644	0,4593
G16	0,5981	0,6851
G17	-10	.
G18	0,2718	1,0675
G19	2,532	0,6611
TYPE informed = 1	0,7064	0,1366
CHI	0,0623	0,4486
RENT 20% = 1	1,7972	0,1517
RATIO 1/15 = 1	-0,6847	0,1261
R1 Round 1	0,6744	0,4972
R2 Round 2	-1,4882	0,6609
R3 …	-0,0578	0,8422
R4	0,0987	0,8411
R5	-0,0955	0,1957
R6	-0,5919	0,3249
R7	-0,0039	0,5806
#A withdrawing one period earlier	0,5434	0,1513

The estimates in G1 until G19 are the estimates of γ coefficients. To illustrate the ‘ pure time’ effect (i.e., the hazard function in period t as a function of the period number only), figure 5 shows this ‘ baseline hazard function’ .

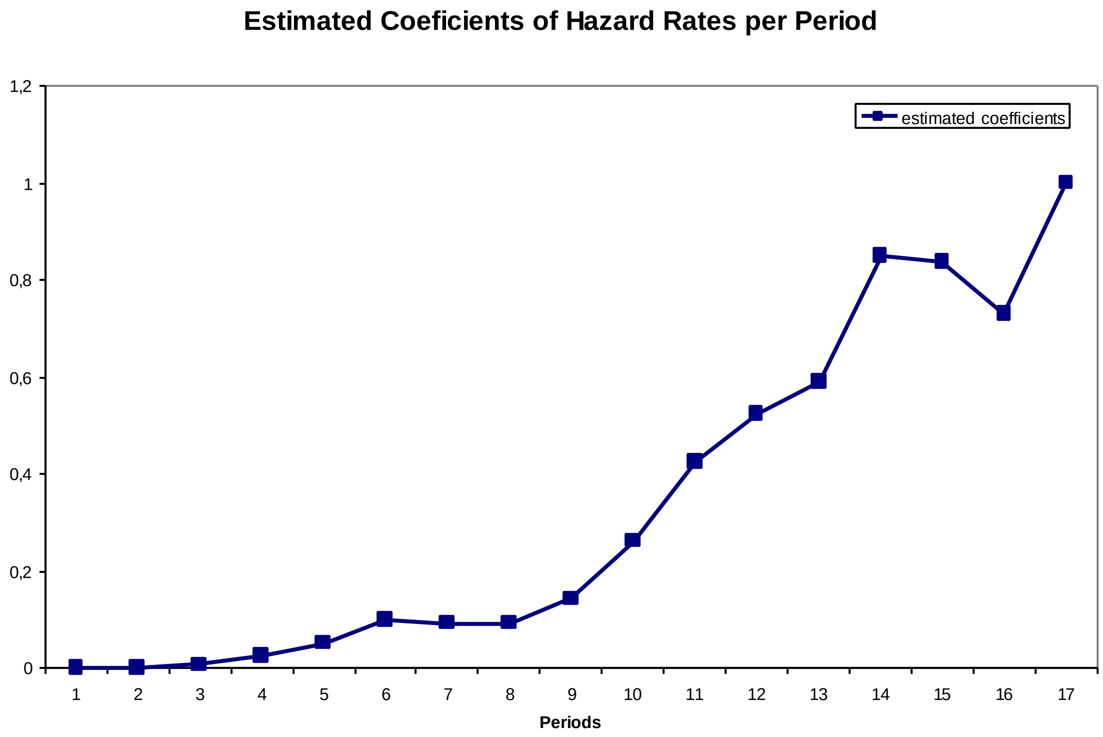

Figure 5

The picture gives the pure effect of hazard due to time passing by. The probability of leaving the scheme increases almost monotonically. Only in periods 15 and 16 do we observe a decrease. This appears to be due to the fact that in these periods, usually only one or a few investors are left. They sometimes decide to stay in the scheme until bankruptcy occurs and the remaining funds are split over 1 or a few participants.

Note in table 1 that for Type, Rent, Ratio, and Rounds are concerned with the time-invariant Z covariates whilst the coefficient for Chi is concerned with the pre-determined variable in X_t. The value of 0.71 for TYPE means that, *ceteris paribus*, the hazard rate is higher for the informed than for the uninformed. The same holds for the coefficient of RENT. This positive value means that a higher rent causes a higher hazard per period i.e. the game lasts shorter. The negative value for

RATIO means that in case of one informed player the hazard per period is lower i.e. the game lasts longer in this case.

It may seem surprising that the hazard rate is higher for informed players, indicating that in any given period, they are more likely to withdraw than the uninformed. The coefficient in the last row corrects the hazard for an uninformed player given that an informed player leaves the game one period earlier. In cases where there are more than one informed player this variable gives the percentage of informed players withdrawing in a period. The positive value for this variable indicates that the hazard for uninformed player increases if uninformed previously withdrew. In other words, uninformed players follow the movements of informed players.

Finally, the coefficients for the carious rounds have the tendency to go towards 0, i.e., to converge towards the base round (8). There seems to be a process of learning in early rounds. In the first round, some players get out very early. This causes the change on the behavior of the players in the second round where they stay much longer. This process of learning by doing is illustrated in figure 6.

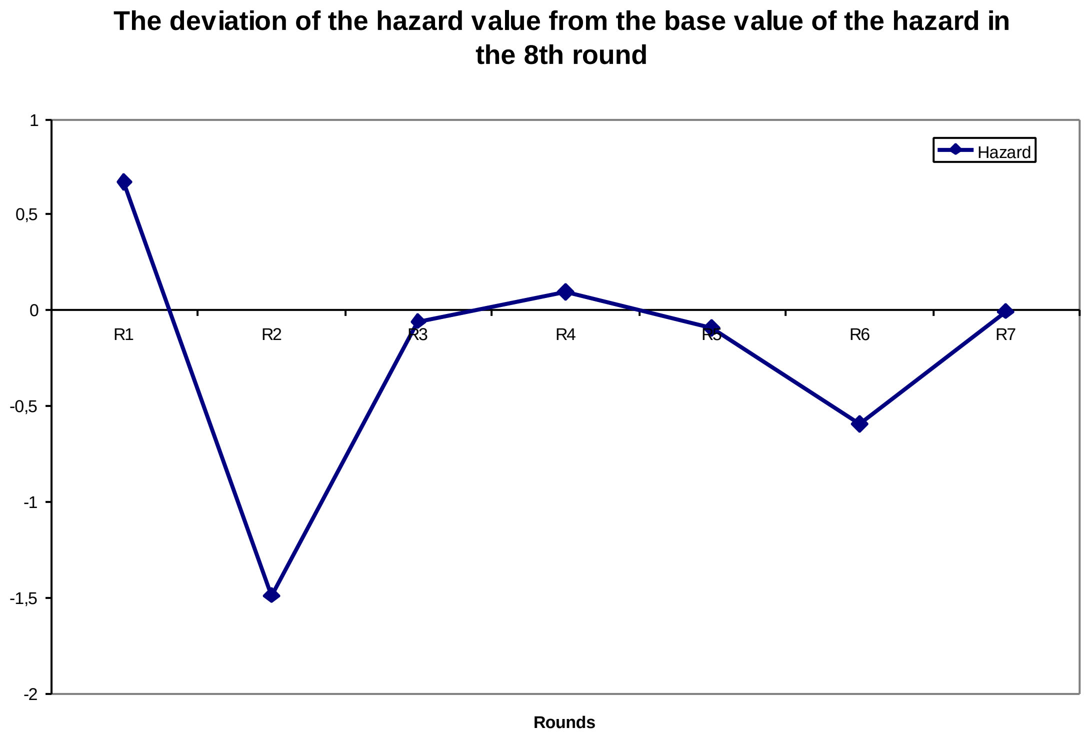

Figure 6

Conclusions

Behavior in out of the laboratory Ponzi schemes is almost impossible to study. Not only are people ashamed to admit that they participated, there is generally no real bookkeeping. Therefore, to study the basic elements of this behavior, the laboratory provides a useful tool. In this paper, we have focused on the effect that the rate of interest and the number of informed investors have on investments in these schemes.

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References