Prize-linked Savings with Guaranteed Winners: Theory and Experiment[1]

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1 Introduction

Low savings rate has long been a concern among economists. Policy makers have been attempting to use several instruments to encourage savings ranging from tax incentive to nudging with a default option. One instrument is an alternative saving vehicle that bundles saving and lottery, so-called Prize Linked Savings (PLS). The PLS accounts holders have a chance to win a prize along with an interest return without losing principal. The interest rate of the PLS accounts is typically lower than the traditional saving account. However, the chance of winning a big prize may be appealing to consumers who regularly purchase lotteries since PLS accounts, equivalently, use a portion of interest return to buy lotteries for the account holders.

The PLS prizes are drawn periodically and the PLS holders would have a chance to win a prize as long as they keep their investment in the account. It is common that the chance of winning the prizes is increasing with the deposit amounts. However, the number of grand prizes is usually fixed regardless of the total amount of the PLS investment, which means that

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the chance of winning the prizes depends on the total pool: the larger the pool, the smaller the chance.[2]

Though marketed for a long time, PLS accounts just gained some interests in academic research recently. Tufano et al. (2011) conducted a survey and concluded that the PLS product might be appealing to the U.S. consumers especially on heavy lottery players, non-savers and those with low savings.

Cole et al. (2016) studied the impact of PLS accounts in South Africa. They found that PLS is attractive to a broad group of individuals especially those with low savings. They did not see any evidence that the PLS account cannibalized traditional savings. In fact, they found the reverse: branches with higher amount of PLS also observed a greater increase in traditional savings, and individuals with the PLS accounts typically increased their balances in traditional savings accounts. However, they could not rule out the fact that the increase in traditional savings from individuals may be because those PLS holders may shift some of their savings from other banks to the bank that offered the PLS accounts for their convenience, as they mentioned in the paper that "although these relationships are not necessarily casual". Our experiments can rule out this possibility and the results support their claim that the PLS does not cannibalize traditional savings. Subjects in our experiments reduce their consumption when the PLS account is available to them. Moreover, when the interest rates are low, subjects invest in the PLS account without reducing their saving in traditional savings accounts.

Cookson (2017) studied how individual gambling expenditures respond to the introduction of the PLS product in Nebraska. He used a difference-in-difference design to show that individuals in counties that offer PLS reduce gambling by at least 3% more than unaffected individuals. This result provides an evidence that individuals view gambling and PLS as substitute products.

Filiz-Ozbay et al. (2015) conducted series of experiments to compare PLS and traditional saving products. They found that the PLS product can better encourage individuals to defer payment as compared to a guaranteed interest payment, especially among male and self-

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[2] For example, the "Million-a-Month Account" (MaMa) offered by First National Bank in South Africa awarded a grand prize of R1,000,000 (approximately $150,000) every month regardless of the amount of the investment in the MaMa account (Cole et al. 2016).

reported lottery buyers. Atalay et al. (2014) reported an increase in total savings and decrease in lottery expenditures after an introduction of the PLS accounts in online experiments. We intentionally design our PLS (L) treatment to be similar to this study. Our descriptive results are similar to theirs.

Dizon and Lybbert (2017) conducted a lab-in-field experiment with Haitian subjects in Port-au-Prince to study the effect of a lotto-linked savings (LLS).[3] They found that subjects save more with the presence of the LLS product and the saving rate is higher when the LLS returned more principal and less lotto gambling. They also found that LLS is more effective on subjects who spent more on the lottery before the introduction of the LLS and who overweight small probabilities.

Unlike other experimental studies, we introduce PLS accounts with guaranteed winners that allow the strategic interaction among PLS depositors. Rather than a known probability of winning the prizes, in our settings, a probability of winning the PLS prize depends on an individual's allocation in the PLS account relative to the total pool. In the presence of negative externalities, the number of PLS account holders become non-trivial. Thus, the strategic choice may make PLS product unappealing to risk- or ambiguity-averse consumers. However, this feature is more similar to the existing PLS products and more practical for financial institutions since it would limit total expenditure for them. With our design, we can also analyze the effectiveness in encouraging savings from different PLS types by varying the number of depositors as well as the number of winners while keeping the total amount of prizes fixed.

We develop a theoretical model to derive each player's best response function in allocating money between early consumption, traditional savings with fixed interest rate, and a PLS account with guaranteed winners. We prove that there exists a unique equilibrium given heterogeneous risk-averse players. We also provide comparative statics results that are comparable with our experimental design. In equilibrium, we show theoretically that an existence of PLS does not increase total savings; however, our experimental results contradict this. Subjects in our experiments significantly increase total savings when PLS is available by more than 20 percentage point. This effect is considerably large; an increase in total savings

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[3] The only difference between LLS and PLS is the LLS does not preserve the principal whereas the PLS does. The minimum return of the LLS in Dizon and Lybbert (2017) ranges from 60-100%.

from an introduction of PLS is even bigger than using a higher interest rate. In addition, when interest rate is low, subjects reduce early consumption to allocate more toward PLS without reducing traditional savings. Our results suggest that PLS would be a cost-effective way in encouraging more savings.

2 Theoretical model

We analyze a two-period model with n players. Each player (also called player i for $i = 1, \dots n$) is given income I_{it} and derives utility from consumption in period t, denoted by $c_{it} \geq 0$, for $t = 1$ and 2. We assume that player i's utility function is given by

$$u_i(c_{it}) = -e^{-\alpha_i c_{it}}$$

where $\alpha_i > 0$. This utility function exhibits strict concavity in c_{it} and constant absolute risk aversion (CARA). In period 1, each player chooses to save $x_i \geq 0$ in a traditional savings account and $y_i \geq 0$ in a prize-linked savings (PLS) account such that $x_i + y_i \leq I_{i1}$. The traditional savings account pays interest in period 2 at rate r. The PLS account does not pay interest, but one of the account holders will be randomly chosen as the prize winner and paid R in period 2. Regardless of whether he wins the prize, he will get y_i back in period 2. Therefore, $c_{i1} = I_{i1} - x_i - y_i$, $c_{i2} = I_{i2} + x_i(1+r) + y_i + R$ if he wins the prize, and $c_{i2} = I_{i2} + x_i(1+r) + y_i$ if he does not win. The probability that player i wins the prize is $y_i/(y_i + Y_{-i})$ where $Y_{-i} = \sum_{j \neq i}^{n} y_j$. We let β_i be player i's discount factor for his utility in period 2 so that his expected utility (EU) over the two periods can be written as

$$U_i(x_i, y_i) = u_i(I_{i1} - x_i - y_i) + \beta_i \frac{y_i}{y_i + Y_{-i}} u_i(I_{i2} + x_i(1+r) + y_i + R) + \beta_i \frac{Y_{-i}}{y_i + Y_{-i}} u_i(I_{i2} + x_i(1+r) + y_i)$$

2.1 PLS Equilibrium

We define $\Delta I_i := I_{i2} - I_{i1}$. Setting $\frac{\partial U_i}{\partial x_i} = 0$ and $\frac{\partial U_i}{\partial y_i} = 0$ yields the first-order conditions:

$$\frac{\beta_i(1+r)}{y_i + Y_{-i}}(y_i e^{-\alpha_i R} + Y_{-i}) = e^{\alpha_i(\Delta I_i + (2+r)x_i + 2y_i)}$$

and

$$\frac{\beta_i}{y_i + Y_{-i}}\left(\frac{Y_{-i}}{y_i + Y_{-i}} \cdot \frac{1 - e^{-\alpha_i R}}{\alpha_i} + y_i e^{-\alpha_i R} + Y_{-i}\right) = e^{\alpha_i(\Delta I_i + (2+r)x_i + 2y_i)}$$

respectively. Let x_i^* and y_i^* be choice variables that satisfy the two conditions above[4]. Since the right-hand sides of the two conditions are identical, we can set the left-hand sides equal to each other, i.e.,

$$\frac{\beta_i(1+r)}{y_i + Y_{-i}}(y_i^* e^{-\alpha_i R} + Y_{-i}) = \frac{\beta_i}{y_i^* + Y_{-i}}\left(\frac{Y_{-i}}{y_i^* + Y_{-i}} \cdot \frac{1 - e^{-\alpha_i R}}{\alpha_i} + y_i^* e^{-\alpha_i R} + Y_{-i}\right)$$

which implies the following quadratic equation:

$$e^{-\alpha_i R} y_i^{*2} + (1 + e^{-\alpha_i R}) Y_{-i} y_i^* + \left[Y_{-i}^2 - Y_{-i}\left(\frac{1 - e^{-\alpha_i R}}{\alpha_i r}\right)\right] = 0$$

Therefore, player i's best response function can be written as the positive solution of the above equation, i.e.,

$$y_i^* = \frac{1}{2e^{-\alpha_i R}}\left[-(1 + e^{-\alpha_i R})Y_{-i} + \sqrt{(1 + e^{-\alpha_i R})^2 Y_{-i}^2 - 4e^{-\alpha_i R}\left[Y_{-i}^2 - Y_{-i}\left(\frac{1 - e^{-\alpha_i R}}{\alpha_i r}\right)\right]}\right]$$

$$= \frac{Y_{-i}}{2e^{-\alpha_i R}}\left[-(1 + e^{-\alpha_i R}) + (1 - e^{-\alpha_i R})\sqrt{1 + \frac{4e^{-\alpha_i R}}{\alpha_i r(1 - e^{-\alpha_i R})Y_{-i}}}\right] \quad (1)$$

given $Y_{-i} \geq 0$.[5] If the positive solution does not exist, then his best response will be zero. Thus, we can say that player *i*'s does not contribute to his PLS account when the bracketed sum in the solution is negative, or equivalently,

$$Y_{-i} \geq \frac{1 - e^{-\alpha_i R}}{\alpha_i r} =: \kappa_i$$

We call this value of Y_{-i} the PLS threshold for player *i* denoted by κ_i. If the sum of other players' PSL is at least κ_i, player *i*'s best response is to save nothing in his PLS account.

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[4] We find that the second-order conditions for x_i^* and y_i^* to be player i's EU maximizing choices hold when ΔI_i is not too small. Specifically, we assume that there exists c<0 such that $\Delta I_i > c$.

[5] If $Y_{-i} = 0$, then player *i*'s best response will be a very small positive value denoted by ε. This will never constitute an equilibrium because each of other players will respond to ε by increasing his PLS and, as a result, $Y_{-i} > 0$.)

Example 1. Consider a situation in which $n = 2$, $r = 0.1$, and $R = 1$. If $\alpha_1 = 1$, then $\kappa_1 = 6.321$. Player 1 will not save in her PLS account given that player 2 has put at least 6.321 in his PLS account. If $\alpha_2 = 2$, then $\kappa_2 = 4.323$. Player 2 will not save in his PLS account given that player 1 has put at least 4.323 in her PLS account.

$$y_i^* = \begin{cases} \frac{y_2}{2e^{-1}}\left[-(1+e^{-1}) + (1-e^{-1})\sqrt{1+\frac{4e^{-1}}{0.1(1-e^{-1})y_2}}\right] & \text{if } y_2 < 6.321 \\ 0 & \text{if } y_2 \geq 6.321 \end{cases}$$

$$y_2^* = \begin{cases} \frac{y_1}{2e^{-2}}\left[-(1+e^{-2}) + (1-e^{-2})\sqrt{1+\frac{4e^{-2}}{0.2(1-e^{-2})y_1}}\right] & \text{if } y_1 < 4.323 \\ 0 & \text{if } y_1 \geq 4.323 \end{cases}$$

See each player's best-response function in Figure 1. The two best-response curves cross at $y_1 = 2.448$ and $y_2 = 1.537$ which is the unique Nash equilibrium of the game (see point A in Figure 1). Total PLS by the two players are 3.985 and the corresponding probabilities of winning the PLS prize are 61.4% for player 1 and 38.6% for player 2.

Example 2. If we instead assume that the two players have the same risk parameters, for example, $\alpha_1 = \alpha_2 = 1$, the two best-response curves will cross at $y_1 = y_2 = 2.310$. As a result, each player has 50% chance of winning the PLS prize (see point B in Figure 1). This equilibrium is symmetric and it is unique.

The above examples demonstrate how we derive an equilibrium of the game when there are two players who may or may not have similar preferences. Next we formally show that the game has a unique equilibrium given n heterogeneous players where $n \geq 2$. We follow Cornes and Hartley's share function approach to identify an equilibrium. Specifically, we define player i's share $s_i(\psi) := \frac{y_i^*}{\psi}$, where $\psi = y_i^* + Y_{-i} > 0$[6], to be his probability of winning the PLS prize corresponding to his best response to Y_{-i}. Note that this probability is written as a function of total PLS by all participants (ψ). It follows that we can derive total PLS in equilibrium by setting the sum of all shares, i.e., $\sum_{i=1}^{n} s_i(\psi)$, equal to one. We call such a value ψ^e and can say that ψ^e is aggregate PLS in equilibrium. It follows that player i

[6] $\psi = 0$ is not possible since player i's best response to $Y_{-i} = 0$ is $\varepsilon > 0$. See also the previous footnote.

saves $s_i\psi^e$ in his PLS account. The following proposition shows that ψ^e is unique so we can say that every PLS game has a unique equilibrium.

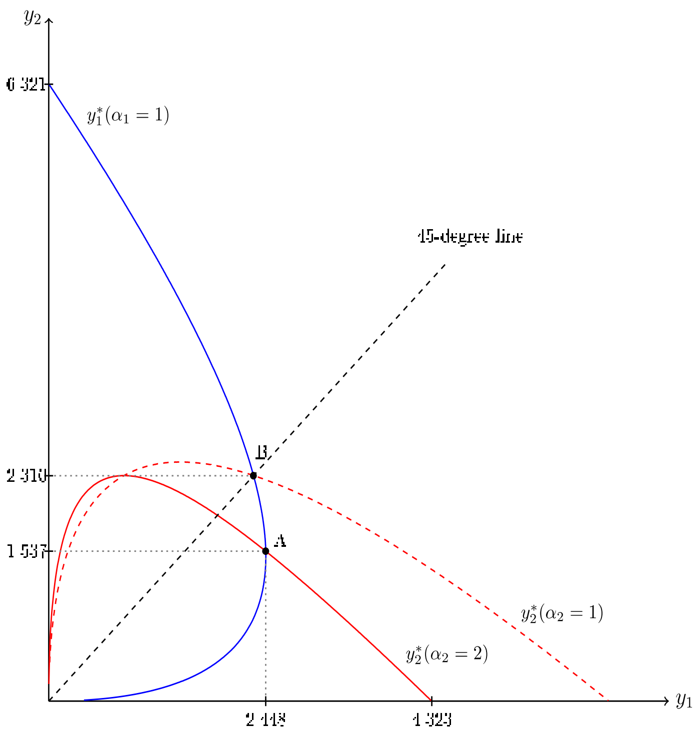

Figure 1. Best response curves and equilibrium

Proposition 1. *Given n heterogeneous CARA players, the PLS game has a unique Nash equilibrium.*

Proof:

Eq (1) implies that player i's optimal PLS amount is y_i^* such that

$$r(y_i^* e^{-\alpha_i R} + Y_{-i}) = \frac{Y_{-i}}{y_i^* + Y_{-i}} \cdot \frac{1 - e^{-\alpha_i R}}{\alpha_i}$$

If we define player i's share $s_i(\psi) := \frac{y_i^*}{\psi}$ where $\psi = y_i^* + Y_{-i}$, the above condition can be written as

$$r[s_i \psi e^{-\alpha_i R} + (1 - s_i)\psi] = (1 - s_i)\frac{1 - e^{-\alpha_i R}}{\alpha_i}$$

which is equivalent to

$$\alpha_i r\psi(s_i e^{-\alpha_i R} - s_i) + s_i(1 - e^{-\alpha_i R}) = 1 - e^{-\alpha_i R} - \alpha_i r\psi$$

Therefore,

$$s_i = \frac{1 - e^{-\alpha_i R} - \alpha_i r\psi}{1 - e^{-\alpha_i R} - (1 - e^{-\alpha_i R})\alpha_i r\psi} = \frac{\kappa_i - \psi}{\kappa_i - (1 - e^{-\alpha_i R})\psi} \tag{2}$$

given $\psi \in (0, \kappa_i)$ and 0 given $\psi \geq \kappa_i$. We find that (i) $s_i \in [0,1)$, (ii) $s_i \to 1$ as $\psi \to 0$, (iii) $s_i \to 0$ as $\psi \to \kappa_i$, and (iv) $\frac{ds_i}{d\psi} = \frac{-\alpha_i r e^{-\alpha_i R}}{(1-e^{-\alpha_i R})(1-\alpha_i r\psi)^2} < 0$ for all $\psi \in (0, \kappa_i)$. It follows that (i) $\sum_{i=1}^{n} s_i \in [0, n)$, (ii) $\sum_{i=1}^{n} s_i \to n$ as $\psi \to 0$, (iii) $\sum_{i=1}^{n} s_i \to 0$ as $\psi \to \hat{\kappa}$ where $\hat{\kappa} := \max \kappa_i$, and (iv) $\sum_{i=1}^{n} s_i$ is strictly decreasing for all $\psi \in (0, \hat{\kappa})$. Thus, there exists a unique value of $\psi \in (0, \hat{\kappa})$ such that $\sum_{i=1}^{n} s_i$, i.e., the sum of probabilities of winning, is equal to 1. ■

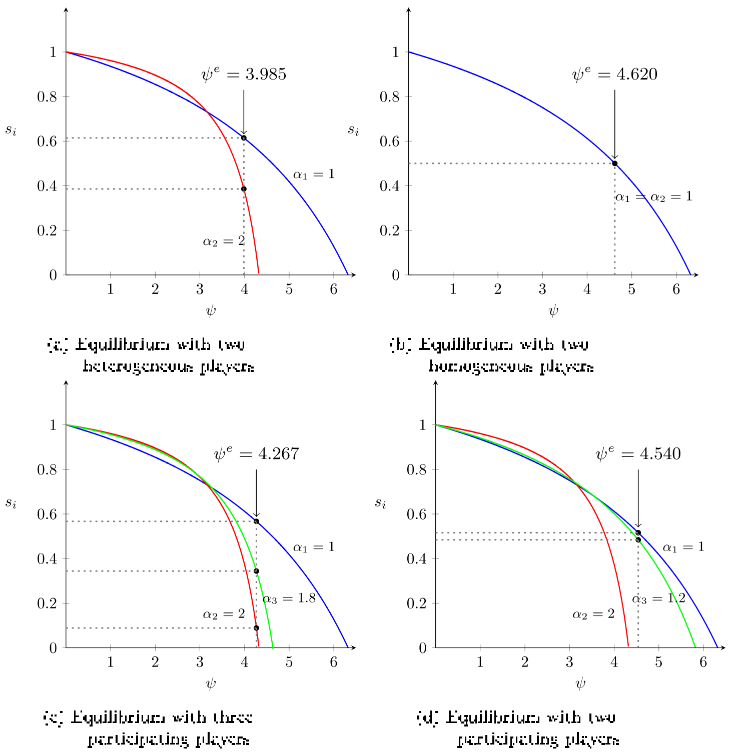

Figure 2. Share functions

Example 1 Revisited. We have $n = 2$, $\alpha_1 = 1$, and $\alpha_2 = 2$. If we use share functions instead of best-response functions to find an equilibrium, we can plot each player's share function as in panel (a) of Figure 2. Each function is strictly decreasing for $\psi \in (0, \kappa_i)$ and there is only one value of ψ such that $s_1 + s_2 = 1$. That value is 3.985, which is the sum of PLS by both players in equilibrium. Since $s_1(3.985) = 61.4\%$, we know that $y_1^e = 61.4\% * 3.985 = 2.448$. Similarly, $s_2(3.985) = 38.6\%$ implies that $y_2^e = 1.537$.

Example 2 Revisited. We have $n = 2$, $\alpha_1 = \alpha_2 = 1$. Each player's share function can be plotted as in panel (b) of Figure 2. It follows that 4.620 is the only value of ψ such that $s_1 + s_2 = 1$. Since $s_1(4.620) = s_2(4.620) = 50.0\%$, we know that $y_1^e = y_2^e = 50.0\% * 4.620 = 2.310$.

Example 3. Let $n = 3$, $\alpha_1 = 1$, $\alpha_2 = 2$, and $\alpha_3 = 1.8$. We can plot each player's share function as in panel (c) of Figure 2. Each function is strictly decreasing for $\psi \in (0, \kappa_i)$ and we find that 4.267 is only one value of ψ such that $s_1 + s_2 + s_3 = 1$. Since $s_1(4.267) = 56.7\%$, $s_2(4.267) = 8.9\%$, and $s_3(4.267) = 34.4\%$, we find that $y_1^e = 2.419$, $y_2^e = 0.379$, and $y_3^e = 1.469$.

Example 4. Let $n = 3$, $\alpha_1 = 1$, $\alpha_2 = 2$, and $\alpha_3 = 1.2$. We can plot each player's share function as in panel (d) of Figure 2. All functions are strictly decreasing for $\psi \in (0, \kappa_i)$ and we find that 4.540 is only value of ψ such that $s_1 + s_2 + s_3 = 1$. Since $\kappa_2 = 4.323 < 4.540$, player 2 will not participate in this equilibrium, i.e., $y_2^e = 0$. Since $s_1(4.540) = 51.6\%$ and $s_3(4.540) = 48.4\%$, we find that $y_1^e = 2.343$ and $y_3^e = 2.198$.

2.2 Comparative Statics

We already know that there exists a unique equilibrium when players are heterogeneous in risk preferences. Now consider a special case when players are homogeneous. If there are n players with $\alpha_i = \alpha$ for all i, we can derive a symmetric equilibrium by substituting $Y_{-i} = (n-1)y_i$ in (1) or setting $s_i = 1/n$ in (2). Either way we can derive each player's PLS deposit amount in a symmetric equilibrium as

$$y_i^e = \frac{(n-1)(1-e^{-\alpha R})}{\alpha n r(n-1+e^{-\alpha R})} \tag{3}$$

Proposition 2. *Properties of* y_i^e*:*

1) $\frac{\partial y_i^e}{\partial \alpha} < 0$
2) $\frac{\partial y_i^e}{\partial r} < 0$
3) $\frac{\partial y_i^e}{\partial R} > 0$
4) $\frac{\partial y_i^e}{\partial n} < 0$ *and* $\lim_{n\to\infty} y_i^e = 0$

Proof:

1) Given $y_i^e = \frac{(n-1)(1-e^{-\alpha R})}{\alpha n r(n-1+e^{-\alpha R})}$, we find $\frac{\partial y_i^e}{\partial \alpha} = \frac{(n-1)}{nr}\left[\frac{n(\alpha R e^{-\alpha R}-1+e^{-\alpha R})+(1-e^{-\alpha R})^2}{\alpha^2(n-1+e^{-\alpha R})^2}\right]$. Let $n = 2$. The numerator inside the brackets can be written as $2(\alpha R e^{-\alpha R} - 1 + e^{-\alpha R}) + (1-e^{-\alpha R})^2 = 2\alpha R e^{-\alpha R} - 1 + e^{-2\alpha R}$. We define $F(a) = e^a - a e^{a/2}$. We know that $F(0) = 1$, $F'(0) = 0$, and $F'(a) > 0$ for all $a \neq 0$. Thus $F(a) < 1$ for all $a < 0$. It follows that $F(-2\alpha R) = e^{-2\alpha R} + 2\alpha R e^{-\alpha R} < 1$ which is equivalent to $2\alpha R e^{-\alpha R} - 1 + e^{-2\alpha R} < 0$. Thus $\frac{\partial y_i^e}{\partial \alpha} < 0$ for $n = 2$. Since $2(\alpha R e^{-\alpha R} - 1 + e^{-\alpha R}) + (1-e^{-\alpha R})^2 < 0$, it is necessary that $\alpha R e^{-\alpha R} - 1 + e^{-\alpha R} < 0$. It follows that $n(\alpha R e^{-\alpha R} - 1 + e^{-\alpha R}) + (1-e^{-\alpha R})^2 < 0$ for all $n > 2$. Therefore, $\frac{\partial y_i^e}{\partial \alpha} < 0$ for any $n \geq 2$.

2) $\frac{\partial y_i^e}{\partial r} = -\frac{(n-1)(1-e^{-\alpha R})}{\alpha n r^2(n-1+e^{-\alpha R})} < 0$.

3) $\frac{\partial y_i^e}{\partial R} = \frac{(n-1)e^{-\alpha R}}{r(n-1+e^{-\alpha R})^2} > 0$.

4) $\frac{\partial y_i^e}{\partial n} = -\frac{(1-e^{-\alpha R})}{\alpha r}\left[\frac{(1-e^{-\alpha R})+n(n-2)}{n^2(n-1+e^{-\alpha R})^2}\right] < 0$. Since Eq (3) implies $y_i^e = \frac{(1-e^{-\alpha R})}{\alpha r[e^{-\alpha R}n/(n-1)+n]}$, it follows immediately that $\lim_{n\to\infty} y_i^e = 0$. ■

Proposition 2 suggests that in a symmetric equilibrium, participants increase their savings in the PLS account as they become less risk-averse, the traditional interest rate decreases, the PLS prize increases, or the number of participants decreases.

Next, we analyze comparative statics on each player's optimal traditional savings. In general, (3) implies that the optimal amount in the traditional savings account for player i is

$$x_i = \frac{\ln(\beta_i(1+r)Z_i) - \alpha_i(\Delta I_i + 2y_i)}{\alpha_i(2+r)}$$

where $Z_i = \frac{y_i e^{-\alpha_i R} + Y_{-i}}{y_i + Y_{-i}}$.

In a symmetric equilibrium where $\alpha_i = \alpha$ for all i and y_i^e is given by (3), we have

$$x_i^e = \frac{\ln\left(\frac{\beta_i(1+r)(n-1+e^{-\alpha R})}{n}\right) - \alpha(\Delta I_i + 2y_i^e)}{\alpha(2+r)}$$

In Figure 3 we plot x_i^o, x_i^e, y_i^e, and $x_i^e + y_i^e$ on R. We assume $\alpha = 1$, $\beta = 0.9$, $I_{i1} = 3$, $I_{i2} = 0$, $r = 0.1$, and $n = 5$.

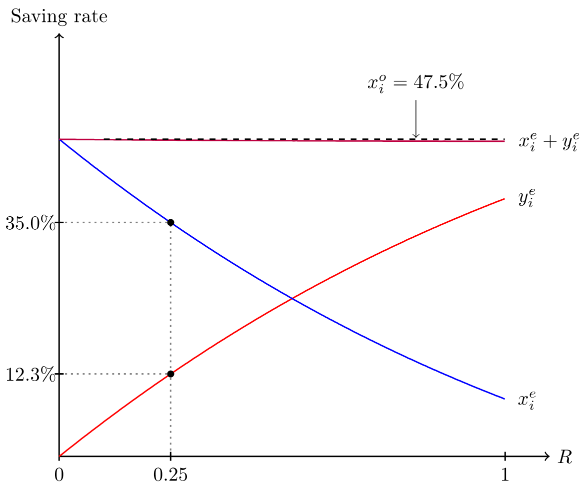

Figure 3. Individual Saving Rates as *R* increases.

When PLS savings are not available (or no prize from saving in a PLS account, i.e., $R = 0$), we find that $y_i = 0$ and

$$x_i^o = \frac{\ln\left(\beta_i(1+r)\right) - \alpha_i \Delta I_i}{\alpha(2+r)}$$

Player *i*'s change in traditional savings when PLS become available can be written as

$$\Delta x_i \coloneqq x_i^e - x_i^o = \frac{1}{\alpha(2+r)}\left[\ln\left(\frac{n-1+e^{-\alpha R}}{n}\right) - \frac{2(n-1)(1-e^{-\alpha R})}{nr(n-1+e^{-\alpha R})}\right] \tag{4}$$

Proposition 3. *Properties of* Δx_i:

1) $\Delta x_i < 0$
2) $\frac{\partial \Delta x_i}{\partial r} > 0$
3) $\frac{\partial \Delta x_i}{\partial R} < 0$
4) $\frac{\partial \Delta x_i}{\partial n} > 0$ *and* $\lim_{n\to\infty} \Delta x_i = 0$

Proof:

1) The inequality follows because each of the terms inside the brackets is negative.

2) The inequality follows because each of the terms inside the brackets is negative.

3) Given Δ in Eq (4), we find that $\frac{\partial \Delta x_i}{\partial R} = -\frac{e^{-2\alpha R}}{(2+r)(n-1+e^{-\alpha R})^2} < 0$.

4) Given Δ in Eq (4), we find that $\frac{\partial \Delta x_i}{\partial n} = \frac{(1-e^{-\alpha R})[n-1+(n+1)e^{-\alpha R}]}{\alpha(2+r)n^2(n-1+e^{-\alpha R})^2} > 0$. Given Δ in Eq (4), we find that each of the two terms in the brackets converges to 0 as n goes to ∞. It follows immediately that $\lim_{n\to\infty} \Delta x_i = 0$.

Now we analyze total savings. If we define $\Delta s_i := x_i^e + y_i^e - x_i^o$, then

$$\Delta s_i = \frac{1}{\alpha(2+r)}\left[\ln\left(\frac{n-1+e^{-\alpha R}}{n}\right) + \frac{(n-1)(1-e^{-\alpha R})}{n(n-1+e^{-\alpha R})}\right] \tag{5}$$

Proposition 4. *Properties of* Δs_i:

1) $\Delta s_i < 0$
2) $\frac{\partial \Delta s_i}{\partial r} > 0$
3) $\frac{\partial \Delta s_i}{\partial R} < 0$
4) $\frac{\partial \Delta s_i}{\partial n} > 0$ *and* $\lim_{n\to\infty} \Delta s_i = 0$

Proof:

1) For $n = 2$, we have $\Delta = \frac{1}{\alpha(2+r)}\left[\ln\left(\frac{1+e^{-\alpha R}}{2}\right) + \frac{(1+e^{-\alpha R})}{2(1+e^{-\alpha R})}\right]$. We define $G(a) = 2\ln a + \frac{1}{a}$. We know that $G(a) < 1$ for all $a \in (\frac{1}{2}, 1)$. Let $a = \frac{1+e^{-\alpha R}}{2}$. Then, $2\ln\left(\frac{1+e^{-\alpha R}}{2}\right) + \frac{2}{1+e^{-\alpha R}} < 1$ which is equivalent to $\ln\left(\frac{1+e^{-\alpha R}}{2}\right) + \frac{(1-e^{-\alpha R})}{2(1+e^{-\alpha R})} < 0$. Thus, $\Delta < 0$ given $n = 2$. In part 2 below, we prove that $\frac{\partial \Delta}{\partial n} > 0$, and $\lim_{n\to\infty} \Delta = 0$. Therefore, $\Delta < 0$ given any $n \geq 2$.

2) Given Δ in Eq (5), we find that $\frac{\partial \Delta}{\partial R} = -\frac{e^{-2\alpha R}}{(2+r)(n-1+e^{-\alpha R})^2} < 0$.

3) Given Δ in Eq (5), we find that $\frac{\partial \Delta}{\partial n} = \frac{(1-e^{-\alpha R})[n-1+(n+1)e^{-\alpha R}]}{\alpha(2+r)n^2(n-1+e^{-\alpha R})^2} > 0$. Given Δ in Eq (5), we find that each of the two terms in the brackets converges to 0 as n goes to ∞. It follows immediately that $\lim_{n\to\infty} \Delta = 0$.

Now suppose that $\frac{R}{n}$ is fixed. In other words, there exists $\lambda > 0$ such that $R = \lambda n$. How would subjects respond to a larger prize and a larger pool of participants when they both change proportionally? Note that $\frac{\partial R}{\partial n} = \lambda$ so we have

$$\frac{dy_i^e}{dn} = \frac{\partial y_i^e}{\partial n} + \frac{\partial y_i^e}{\partial R}\lambda$$

Since $\frac{\partial y_i^e}{\partial n} < 0$ while $\frac{\partial y_i^e}{\partial R} > 0$, then the sign of $\frac{dy_i^e}{dn}$ is ambiguous. But we know that given $R = \lambda n$, $R \to \infty$ as $n \to \infty$. It follows that $y_i^e \to 0$.

In Figure 4 we plot x_i^o, x_i^e, y_i^e, and $x_i^e + y_i^e$ on R. We assume $\alpha = 1$, $\beta = 0.9$, $r = 0.1$, and $\lambda = 0.05$. As we increase the value of R from 0.1 to 1, the corresponding value of n is increased from 2 to 20. Note that when $R = 0.25$, we have $n = 5$, $x_i^e = 35.0\%$, $y_i^e = 12.3\%$ as Figure 3.

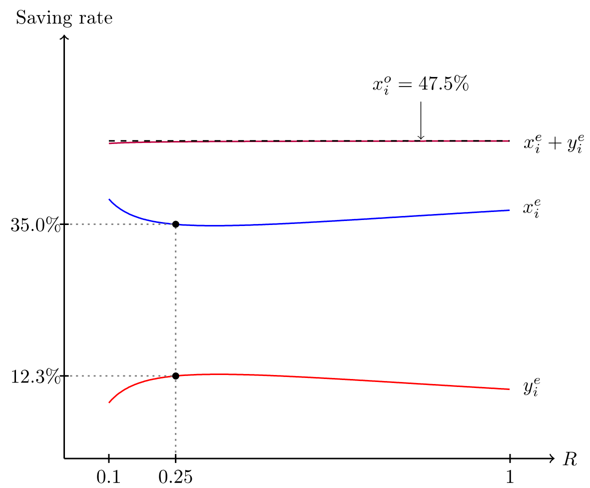

Figure 4. Individual Saving Rates as R increases given $R = 0.05n$.

2.3 Hypotheses

Based on Propositions 2 to 4 and our experimental design, we can test the following hypotheses.

1.1 As PLS prize increases, subjects increase PLS savings.

1.2 As interest rate increases, subjects decrease PLS savings.

2.1 When PLS become available, subjects decrease traditional savings.

2.2 As PLS prize increases, the difference between traditional savings before and after PLS become available increases.

2.3 As interest rate increases, the difference between traditional savings before and after PLS become available decreases.

3.1 When PLS become available, subjects decrease total savings.

3.2 As PLS prize increases, the difference between total savings before and after PLS become available increases.

3.3 As interest rate increases, the difference between total savings before and after PLS become available decreases.

3 Experiment

3.1 Experimental design

The experiment consisted of a series of 49 individual allocation decisions in which each subject always had 300 THB.[7] There were five sets of scenarios: Baseline, PLS (L), PLS (1/5), PLS (1/20) and PLS (4/20). Two or three potential alternatives were available for subjects to allocate their budget: (1) receiving cash two weeks from the date of the experiment (early payment), (2) traditional savings (with fixed interest rate) and (3) a PLS account (no interest but with a possibility of winning a prize). Money allocated to traditional savings was paid 26 weeks from the date of the experiment and included the principal plus interest (r) which was 0.25%, 0.5%, 0.75%, 1% or 1.25%[8] across the scenarios as shown in Table 1. This type of saving was always available in all scenarios. In the baseline (the first five scenarios), subjects could allocate money between an early consumption and a traditional saving account with different interest rates across the scenarios.

[7] At the time of the experiments, the exchange rate was about 35 THB/USD and the minimum wage in Thailand was 300 THB per day.

[8] The interest rate for a standard savings account and a 6-month fixed deposit account at the Siam Commercial Bank (SCB) was 0.5% and 1.15% per year, respectively, at the time of experiment. Each subject owned a standard savings account with SCB and received her payments from this account.

In all other scenarios, subjects could allocate money among three alternatives: early consumption, traditional savings (same as a baseline) and a PLS account. Money allocated to the PLS account provided a guaranteed payoff of the principle investment plus a chance of winning a lottery prize. Subjects would receive the principal invested in this PLS account along with the prize (if won) 26 weeks from the date of the experiment (the same day as the traditional savings).

In PLS (L), each 1 THB deposited in the PLS account increases the chance of winning a prize by 0.1 percentage point. Thus, a subject who deposited a maximum of 300 THB in this PLS account would have a 30% chance to win the prize. For each interest rate of the traditional savings, three different levels of lottery prizes were offered: Fair (F), Good (G), and Bad (B). The fair prize yields the same expected return as the traditional savings whereas the good and bad prizes yield higher and lower expected returns by 0.25 percentage point, respectively.[9] We varied the PLS prizes to examine the demand for the PLS account under different market conditions where it would be more or less attractive relative to the traditional savings. Our PLS (L) account was similar to the one Atalay et al. (2014) used in their experiment except that we varied the PLS prizes but kept the odds unchanged while they varied the odds but kept the PLS prizes unchanged.

Table 1. Summary of scenarios

Set	Scenario	Traditional savings interest rate	PLS prize
Baseline	Baseline 1	0.25%	-
	Baseline 2	0.50%	-
	Baseline 3	0.75%	-
	Baseline 4	1.00%	-
	Baseline 5	1.25%	-
PLS (L)	PLS (L) 1F	0.25%	2.50
	PLS (L) 1G	0.25%	5.00
	PLS (L) 2B	0.50%	2.50
	PLS (L) 2F	0.50%	5.00
	PLS (L) 2G	0.50%	7.50
	PLS (L) 3B	0.75%	5.00
	PLS (L) 3F	0.75%	7.50
	PLS (L) 3G	0.75%	10.00

[9] When a traditional saving had a 0.25% interest rate, we could only have two scenarios: fair and good prizes for PLS since a bad prize would result in a zero expected return or a zero lottery prize. Therefore, there were 14 scenarios with PLS (L).

	PLS (L) 4B	1.00%	7.50
	PLS (L) 4F	1.00%	10.00
	PLS (L) 4G	1.00%	12.50
	PLS (L) 5B	1.25%	10.00
	PLS (L) 5F	1.25%	12.50
	PLS (L) 5G	1.25%	15.00
PLS (1/5)	PLS (1/5) 1L	0.25%	1.25
	PLS (1/5) 1H	0.25%	2.50
	PLS (1/5) 2L	0.50%	2.50
	PLS (1/5) 2H	0.50%	5.00
	PLS (1/5) 3L	0.75%	3.75
	PLS (1/5) 3H	0.75%	7.50
	PLS (1/5) 4L	1.00%	5.00
	PLS (1/5) 4H	1.00%	10.00
	PLS (1/5) 5L	1.25%	6.25
	PLS (1/5) 5H	1.25%	12.50
PLS (1/20)	PLS (1/20) 1L	0.25%	5.00
	PLS (1/20) 1H	0.25%	10.00
	PLS (1/20) 2L	0.50%	10.00
	PLS (1/20) 2H	0.50%	20.00
	PLS (1/20) 3L	0.75%	15.00
	PLS (1/20) 3H	0.75%	30.00
	PLS (1/20) 4L	1.00%	20.00
	PLS (1/20) 4H	1.00%	40.00
	PLS (1/20) 5L	1.25%	25.00
	PLS (1/20) 5H	1.25%	50.00
PLS (4/20)	PLS (4/20) 1L	0.25%	1.25
	PLS (4/20) 1H	0.25%	2.50
	PLS (4/20) 2L	0.50%	2.50
	PLS (4/20) 2H	0.50%	5.00
	PLS (4/20) 3L	0.75%	3.75
	PLS (4/20) 3H	0.75%	7.50
	PLS (4/20) 4L	1.00%	5.00
	PLS (4/20) 4H	1.00%	10.00
	PLS (4/20) 5L	1.25%	6.25
	PLS (4/20) 5H	1.25%	12.50

PLS (1/5) differed from PLS (L) in that the prize winner was randomly drawn from a pool of 5 subjects. A probability of winning the prize for an individual was equal to the total amount of her allocation in the PLS divided by the total allocation across the pool. In other words, PLS (1/5) guaranteed that there must be only one winner from the pool regardless of the total amount of allocation. Of course, with an exception that if no one in the pool allocated any money to this PLS account, no prize would be awarded. For each interest rate of the traditional savings, two different levels of lottery prizes were offered: Low (L) and High (H). The low prize yielded the same expected return as the traditional savings if one-third of the endowment (an average of 100 THB per person) was allocated to this account.[10] The expected return from the PLS (1/5) would be higher (lower) than the traditional savings if less (more) money was allocated to this account. In the scenarios with high prizes (H), the prizes were two times the prizes in the scenarios with low prizes. The amounts of the high prizes in PLS (1/5) were identical to the fair prizes in PLS (L). Since there were 2 levels of prizes for each interest rate of the traditional savings, there were a total of ten scenarios.

PLS (1/20) and PLS (4/20) were similar to the PLS (1/5) but instead of 5 subjects there were 20 subjects in the pool. One and four winners would receive the prizes in the PLS (1/20) and PLS (4/20), respectively. An individual could win at most only one prize from four identical prizes in the PLS (4/20). A probability of winning the prize for an individual would be calculated in a similar way as in the case of the PLS (1/5). Since there were four times as many subjects in the pool, the prizes for the PLS (1/20) were four times as high as the PLS (1/5) to guarantee the same total amount of prizes between them. For the same reason, each prize of the PLS (4/20) was the same as the PLS (1/5). By keeping the total amounts of the prizes the same across three methods of allocating prizes, we are able to compare the effectiveness of each method.

3.2 Experimental procedures

We conducted two experimental sessions in February and March 2017 at the Center for Behavioral and Experimental Economics (CBEE), Chulalongkorn University. We recruited 80 undergraduate students at Chulalongkorn University to participate in one of the two sessions, with 40 subjects each. All sessions were conducted in a computer lab with cubicles using the software z-Tree (Fischbacher, 2007). To receive money, each subject had to provide a bank account number in which the experimenters would transfer money to. In addition, each subject was asked to complete a survey at the end of the experiment. The experimental instructions and the survey are in sections 7.2 and 7.3, respectively.

[10] There were three alternatives, if each subject allocated money equally for each option, the expected return from the PLS (1/5) would be the same as the traditional savings.

After the end of the experiment, one scenario was randomly selected to determine each subject's early and late payments according to her allocation decision. In addition, each subject received 100 THB as a show-up fee, which was split equally between early and late payments (50 THB each). The early and late payments were transferred to subjects' bank accounts in 2 and 26 weeks after the date of the experiment, respectively. We chose to pay a show-up fee twice to ensure that all subjects would receive payments twice regardless of their decisions. If there were any additional costs in receiving money twice instead of once, a subject could not avoid these costs by choosing to allocate all money in one payment since she would receive a minimum of 50 THB for each payment from a show-up fee. Each subject receives a total compensation of 402 THB on average.

In order to avoid a possible order effect, we conducted two sessions with different orders of scenarios as shown in Table 2. In session 1, we first started an experiment with a baseline in which a PLS account was not available and introduced it in later scenarios. In contrast, in session 2, we first started with a scenario in which a PLS account was available and ended with a baseline.

Table 2. Order of scenarios in each session

Session	Set				
	1	2	3	4	5
1	Baseline	PLS (L)	PLS (1/5)	PLS (1/20)	PLS (4/20)
2	PLS (L)	PLS (1/5)	PLS (1/20)	PLS (4/20)	Baseline

4 Experimental results

Table A1 in an appendix summarizes descriptive characteristics of subjects. These characteristics were self-reported by subjects at the end of the experiments. All subjects were undergraduate students and 42% of them were male. Three quarters of subjects had never purchased a lottery or played a gamble. Only 30% of subjects had purchased a PLS product before and 15% of them had a PLS product at the time of the experiment.

4.1 Traditional savings and PLS

We commence by showing the effect of PLS on a saving rate, defined as the sum of savings in traditional savings and PLS if available divided by the endowment of 300.

Result 1. *Holding the interest rate constant, PLS increases the savings rate. However, the savings rates are not significantly different across scenarios with different PLS.*

Table 3 presents the average saving rate in each scenario. It is clear from the table that an existence of PLS accounts results in a greater saving rate. In the Baseline scenarios, subjects on average put 35.4% to 58.2% of endowment in traditional savings and the savings rate is increasing in the interest rate, as expected. When PLS is available, the savings rate is at least 63%. Using paired-sample t-test of mean difference, each scenario with PLS yields significantly higher saving rate than the corresponding baseline scenario at 1% significance level.

Table 3. Average savings rate

Interest rate	Baseline	PLS (L)			PLS (1/5)		PLS (1/20)		PLS (4/20)	
		Good	Fair	Bad	High	Low	High	Low	High	Low
0.25%	0.354 (0.375)	0.677 (0.388)	0.667 (0.395)	-	0.677 (0.410)	0.675 (0.413)	0.666 (0.418)	0.653 (0.431)	0.647 (0.428)	0.639 (0.429)
0.50%	0.381 (0.371)	0.737 (0.375)	0.700 (0.390)	0.674 (0.388)	0.701 (0.394)	0.683 (0.410)	0.714 (0.398)	0.662 (0.418)	0.675 (0.422)	0.652 (0.429)
0.75%	0.446 (0.389)	0.753 (0.358)	0.703 (0.385)	0.694 (0.383)	0.734 (0.382)	0.697 (0.402)	0.733 (0.385)	0.695 (0.408)	0.705 (0.399)	0.673 (0.426)
1.00%	0.496 (0.398)	0.758 (0.353)	0.726 (0.370)	0.730 (0.371)	0.748 (0.370)	0.713 (0.390)	0.770 (0.370)	0.719 (0.389)	0.708 (0.398)	0.705 (0.404)
1.25%	0.582 (0.410)	0.787 (0.333)	0.766 (0.352)	0.757 (0.351)	0.773 (0.367)	0.719 (0.388)	0.805 (0.341)	0.725 (0.387)	0.764 (0.373)	0.734 (0.390)

Notes: 1. Standard deviations are shown in parentheses.
2. Standard errors are shown in parentheses.
3. The number of samples in each scenario is 80.
4. Using t-test of mean difference, the savings rate in each PLS scenario is significantly higher than that in the corresponding Baseline scenario with $p < 0.001$.

We also estimate the following model of total savings.

$$S_{ij} = \delta^L PLS_j^L + \delta^{1/5} PLS_j^{1/5} + \delta^{1/20} PLS_j^{1/20} + \delta^{4/20} PLS_j^{4/20} + \boldsymbol{X}_j' \boldsymbol{\beta} + \varepsilon_{ij}$$

The variable S_{ij} is individual i's total savings in scenario j calculated from a percentage of money allocated to traditional savings and PLS. PLS_j^k is a dummy variable which is equal to 1 when scenario j has PLS of type k and δ^k is its corresponding coefficient. $\boldsymbol{X}_j$ is a vector of other control variables including interest rate dummy variables, PLS prize indicators—fair, good and bad prize indicators for PLS (L), and low and high prize indicator for other PLS types – where 0.25% interest rate, fair PLS (L) prize and low prizes for all other PLS types are taken as the base case and $\boldsymbol{\beta}$ is a vector of coefficients. ε_{ij} is the error term. We also include a session dummy variable in Model (1) and an individual fixed-effect variable in Model (2).

Table 4 shows estimation results using OLS estimations for models (1) and (2). We observe very similar results between the two models but Model (2) significantly reduces the standard errors, which results in all key variables becoming statistically significant. This indicates that subject heterogeneity plays an important role in explaining the saving rate. As expected, in both models, the saving rate is increasing with higher interest rates as well as higher PLS prizes. However, these effects are relatively small compared to the effect of introducing the PLS account. Apparently, the availability of any PLS types significantly increases the saving rate by more than twenty percentage point. In addition, we observe that a single-prize PLS is more attractive than a multiple-prize PLS in inducing saving: the marginal effect of PLS (4/20) is significantly smaller than other PLS accounts ($F = 11.12, p < 0.01$ for PLS (L), $F = 6.10, p = 0.01$ for PLS (1/5) and $F = 7.38, p < 0.01$ for PLS (1/20)) whereas the effects of three other PLS types: PLS (L), PLS (1/5) and PLS (1/20) are not significantly different ($F = 1.06, p = 0.345$).

Since the savings rate is bounded between zero and one, we also specify the savings equation with generalized linear model (GLM) with binomial distribution and logit link function. The estimation result with maximum likelihood is shown in Model (3) in Table 4. Using a likelihood-ratio test, Result 1 still holds.

Table 4. The treatment effects on saving rate

Variable	(1)	(2)	(3)
	OLS	OLS	GLM
Constant	0.473**	0.688**	1.254**
	(0.024)	(0.027)	(0.410)
PLS (L)	0.261**	0.261**	2.653**
	(0.027)	(0.013)	(0.177)
PLS (1/5)	0.245**	0.245**	2.455**
	(0.025)	(0.011)	(0.164)
PLS (1/20)	0.247**	0.247**	2.483**
	(0.025)	(0.011)	(0.169)
PLS (4/20)	0.223**	0.223**	2.185**
	(0.025)	(0.011)	(0.164)
Interest rate = 0.5%	0.028	0.028**	0.309**
	(0.020)	(0.009)	(0.093)
Interest rate = 0.75%	0.053**	0.053**	0.608**
	(0.020)	(0.009)	(0.095)
Interest rate = 1%	0.077**	0.077**	0.904**
	(0.020)	(0.009)	(0.101)
Interest rate = 1.25%	0.111**	0.111**	1.363**
	(0.020)	(0.009)	(0.112)
Bad PLS (L) prize	-0.012	-0.012*	-0.153
	(0.029)	(0.013)	(0.131)

Good PLS (L) prize	0.030 (0.027)	0.030** (0.013)	0.395** (0.141)
High PLS (1/5), PLS (1/20) or (4/20) prize	0.032* (0.016)	0.032** (0.007)	0.393** (0.070)
Session dummy	-0.151** (0.012)	-	-
Subject fixed-effect	No	Yes	Yes
R-squared	0.086	0.807	-
Pseudo likelihood	-	-	-816.67

Notes: 1. * and ** indicate significance at 5% and 1% levels, respectively.
2. Standard errors are shown in parentheses.
3. The number of observations in all models is 3,920.
4. The base case is 0.25% interest rate, fair PLS (L) prize and low PLS (1/5), PLS (1/20) or (4/20) prize.

Result 2. *PLS significantly crowds out traditional savings only in scenarios with high interest rates.*

We estimate five regressions of traditional savings rate, one for each interest rate, with the same independent variables as Model (2). Table 5 shows the estimated coefficients of PLS dummy variables. With the interest rate of 0.25% and 0.50%, the effects of any PLS on the traditional savings rate are not statistically significant. Together with Result 1, at lower interest rate, PLS does not crowd out traditional savings but rather shifts early payment to PLS. In contrast, there are substitution effects between traditional savings and PLS in the higher interest rate scenarios but the increase in PLS is greater the reduction in traditional savings which results in an increase in total savings. When PLS is not available, a saving rate is high when an interest rate is high, thus there is a smaller room for subjects to shift their consumption toward PLS when PLS is available. This could be a main reason why we observe a decrease in traditional savings only when the interest rates are high and not when the interest rates are low. This result suggests that PLS will be successful in increasing a saving rate without reducing traditional savings especially when a saving rate is low and when an interest rate is low.

Table 5. Marginal effects of PLS on traditional savings rate

PLS type	Interest rate				
	0.25%	0.50%	0.75%	1.00%	1.25%
PLS (L)	-0.031 (0.042)	-0.065 (0.041)	-0.141** (0.042)	-0.051 (0.039)	-0.192** (0.041)
PLS (1/5)	0.052 (0.038)	0.048 (0.038)	-0.009 (0.039)	-0.027 (0.036)	-0.104** (0.038)
PLS (1/20)	0.020 (0.038)	0.003 (0.038)	-0.095* (0.039)	-0.114** (0.036)	-0.194** (0.038)

PLS (4/20)	0.072 (0.038)	0.053 (0.038)	-0.028 (0.039)	-0.021 (0.036)	-0.114** (0.038)

Notes: 1. * and ** indicate significance at 5% and 1% levels, respectively.
2. Standard errors are shown in parentheses.
3. The number of observations is 720 when interest rate is 0.25% and 800 in all other interest rates.
4. Estimates of other coefficients are omitted.

Result 3. *PLS reduces the number of non-savers.*

Table 6 reports subjects' allocation decisions. Without PLS, only one-fifth of decisions had no consumption at all; however, when PLS was available, more than one half of decisions had no consumption. In addition, percent of decisions without saving (consumption = 100%) significantly decrease from 29.3% to 15-18% after PLS was available. This implies that PLS can encourage almost one half of non-savers to reduce some of their early consumption.

Table 6. Subjects Allocation Decisions

Allocation	Percent of Decisions					
	Baseline	PLS (L)	PLS (1/5)	PLS (1/20)	PLS (4/20)	All
Consumption = 0%	20.8	52.0	53.0	54.0	51.5	49.3
Consumption = 100%	29.3	15.7	18.3	15.8	18.6	18.2
Traditional savings = 0%	29.3	31.3	30.1	35.8	31.3	31.7
Traditional savings = 100%	20.8	10.3	19.5	15.9	19.8	16.3
PLS = 0%	-	28.3	40.4	35.4	40.6	31.8
PLS = 100%	-	13.6	9.6	14.8	10.0	10.9
Deposit in traditional savings only	70.7	12.6	22.1	19.6	22.0	18.5
Deposit in PLS only	-	15.5	11.9	20.0	12.6	15.1
Deposit in both	-	56.2	47.8	44.6	46.8	51.7
Number of observations	400	1,120	800	800	800	800

4.2 Rejecting Expected Utility Model

We estimate the parameters in the equilibrium portfolio allocation assuming that subjects are homogenous. All models are estimated with the non-linear least squares estimator. First, we estimate α and β in the baseline scenarios with the following traditional savings specification.

$$x_i^o = \frac{\ln\big(\beta_i(1+r)\big)+\alpha_i}{\alpha(2+r)} + \varepsilon_i$$

As shown in Model (4) in Table 6, the result suggests that subjects are on average risk-averse and they discount future payment slightly.

With the same underlying expected utility theory, we estimate α in PLS (1/5), PLS (1/20) and PLS (4/20) scenarios using the following PLS specification.

$$y_i^e = \frac{(n-1)(1-e^{-\alpha R})}{\alpha nr(n-1+e^{-\alpha R})} + \varepsilon_i$$

As shown in Model (5) in Table 6, the estimate of α is larger than in Model (4), which means that subjects are more risk-averse when PLS is available. In addition, the estimate of β is greater than one ($F = 7.23, p < 0.01$), which means that subjects discount early payment rather than future payment. Since subjects could receive early payment and spend later, an implication of discounting early payment may not be reasonable. We can conclude that subjects' behavior, when PLS is available, are not consistent with the underlying expected utility theory. This is not surprising given the fact that many subjects allocate a large amount of money into a PLS account.

Table 6. Estimated parameters in equilibrium portfolio allocation

Parameter	(4) x^o	(5) $x^e + y^e$
α	0.021**	0.051**
	(0.005)	(0.012)
β	0.991**	1.014**
	(0.001)	(0.005)
R-squared	0.584	0.759
Scenarios	Baseline	PLS (1/5), PLS (1/20) and PLS (4/20)
Obs.	400	2,400

Notes: 1. * and ** indicate significance at 5% and 1% levels, respectively.
2. Standard errors are shown in parentheses.
3. α is a risk-averse parameter (subjects are risk-averse if $\alpha > 0$) and β is a discount factor.

5 Future works

We investigate the effect of PLS on savings behavior both theoretically and experimentally. Although the theory suggests that introduction of PLS reduces savings, the experimental results show that PLS significantly increases savings. In addition, PLS does not crowd out traditional savings especially when the interest rate is low. Apparently, the observed behavior is inconsistent with the theoretical model with expected utility theory. We still need to reconcile the theoretical model by incorporate behavioral economic assumptions. This would provide more insight into why PLS could induce savings without considerably cannibalizing traditional savings.

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7 Appendix

7.1 Additional Table

Table A1. Descriptive Characteristics of Subjects

Characteristics	Fraction of subjects	Characteristics	Fraction of subjects
Gender		Saving rate	
Male	0.42	< 10%	0.21
Female	0.58	10-20%	0.31
Age		20-30%	0.26
18-19	0.15	30-40%	0.13
20-21	0.63	40-50%	0.01
22-23	0.20	> 50%	0.08
24-26	0.02	Lottery	
Department		Never	0.73
Science	0.28	Once in a while	0.24
Economics	0.20	Few times a year	0.01
Accounting	0.13	Every month	0.02
Psychology	0.11	Every week	0.00
Engineering	0.08	Gamble	
Political Science	0.08	Never	0.75
Arts	0.05	Once in a while	0.16
Other	0.07	Few times a year	0.05
Year		Every month	0.03
First	0.12	Every week	0.01
Second	0.39	Has bought PLS	
Third	0.26	Yes	0.30
Fourth	0.23	No	0.70
Cognitive score		Currently has PLS	
0	0.35	Yes	0.15
1	0.22	No	0.85
2	0.19		
3	0.24		

Notes: 1. Number of observations is 80.
2. Other departments include Agriculture, Architect, Communications, Health Science, Laws, Medicine, and Sport Science.

7.2 Instructions

คำอธิบายการทดลอง

ยินดีต้อนรับสู่การทดลองการตัดสินใจ คุณจะได้รับค่าตอบแทนจากการทดลอง ซึ่งจะถูกโอนเข้าบัญชีธนาคารไทยพาณิชย์ของคุณตามเลขบัญชีที่คุณได้กรอกในใบแจ้งค่าตอบแทนจากการทดลอง ค่าตอบแทนจากการทดลองจะแบ่งเป็นสองส่วน ได้แก่

1) ค่าเข้าร่วมการทดลองและตอบแบบสอบถามเป็นจำนวน 100 บาท ซึ่งคุณจะได้รับเงินงวดแรกจำนวนครึ่งหนึ่ง (50 บาท) ใน 2 สัปดาห์นับจากวันนี้ และงวดที่สองเป็นจำนวนครึ่งหนึ่ง (50 บาท) ใน 26 สัปดาห์นับจากวันนี้

2) ค่าตอบแทนจากการตัดสินใจเป็นจำนวนอย่างน้อย 300 บาท ซึ่งคุณจะได้รับโอนงวดแรกในอีก 2 สัปดาห์หรืองวดที่สองในอีก 26 สัปดาห์นับจากวันนี้ หรือได้รับโอนบางส่วนในงวดแรกและส่วนที่เหลือในงวดที่สอง ทั้งนี้ค่าตอบแทนที่คุณจะได้รับในแต่ละงวดจะเป็นเท่าใดจะขึ้นอยู่กับการตัดสินใจของคุณในการทดลอง

วันนี้คือวันที่___________________

งวดแรก (2 สัปดาห์นับจากวันนี้) คือวันที่___________________________

งวดที่สอง (26 สัปดาห์นับจากวันนี้) คือวันที่________________________

การทดลองนี้ประกอบไปด้วย 2 ส่วน ส่วนแรกคือการทดลองการตัดสินใจ ซึ่งจะใช้เวลาไม่เกิน 1 ชั่วโมง และส่วนที่ 2 คือแบบสอบถามซึ่งจะใช้เวลาไม่เกิน 30 นาที

ส่วนที่ 1 การทดลองการตัดสินใจ

ส่วนที่ 1 ประกอบด้วยชุดคำถาม 5 ชุด ซึ่งจะมีสถานการณ์ทั้งหมด 49 สถานการณ์ให้คุณตัดสินใจ ระบบจะสุ่มเลือกสถานการณ์ 1 สถานการณ์จาก 49 สถานการณ์เพื่อนำมาคำนวณเป็นค่าตอบแทนจากการตัดสินใจของคุณ เนื่องจากคุณไม่ทราบว่าค่าตอบแทนของคุณจะคำนวณจากสถานการณ์ใดใน 49 สถานการณ์ ดังนั้น คุณควรจะตัดสินใจอย่างรอบคอบในสถานการณ์ทุก ๆ สถานการณ์ สถานการณ์จะแบ่งเป็นชุด A ถึงชุด E ดังนี้

สถานการณ์ชุด A

สถานการณ์ชุด A ประกอบด้วยสถานการณ์ 14 สถานการณ์ A1 ถึง A14 ในแต่ละสถานการณ์ คุณจะต้องเลือกแบ่งเงิน 300 บาทเป็นสามก้อน ได้แก่ เงินที่จะรับในงวดแรก เงินออมแบบ ก

และเงินออมแบบ ข คุณจะได้รับเงินงวดแรกในอีก 2 สัปดาห์ และคุณจะได้รับคุณจะได้รับเงินออมแบบ ก และแบบ ข พร้อมผลตอบแทนในอีก 26 สัปดาห์ เงินออมแบบ ก จะจ่ายดอกเบี้ยเงินออมแตกต่างกันในแต่ละสถานการณ์ ส่วนเงินออมแบบ ข จะไม่จ่ายดอกเบี้ย แต่คุณมีโอกาสที่จะได้รับรางวัลเป็นเงินที่จะได้รับในงวดที่สองพร้อมเงินต้น โดยคุณจะมีโอกาสได้รับรางวัลเพิ่มขึ้น 0.1% สำหรับ เงินทุก ๆ บาทที่คุณออมในบัญชีนี้

ตัวอย่างเช่น ในสถานการณ์ A1 ซึ่งดอกเบี้ยเท่ากับ 0.25% คุณเลือกรับเงิน 100 บาทในงวดแรก ออมเงินในบัญชี ก เป็นจำนวน 100 บาท และออมเงินในบัญชี ข เป็นจำนวน 100 บาท คุณจะได้ค่าตอบแทนจากการทดลอง 50 + 100 = 150 บาท ในงวดแรก และ 50 + 100 + 1.25 + 100 + 15= 266.75 บาทในงวดที่สองถ้าถูกรางวัล หรือ 50 + 100 + 1.25 + 100 = 251.25 บาทในงวดที่สองถ้าไม่ถูกรางวัล (ดอกเบี้ย 1.25% จากเงินต้นในบัญชี ก 100 บาท เท่ากับ 1.25 บาท และรางวัลเงินต้นในบัญชี ข เท่ากับ 15 บาท) คุณจะมีโอกาสถูกรางวัลจากออมเงินในบัญชี ข 0.1% × 100 = 10%

ในหน้าจอของคุณ คุณจะต้องเลือกเงินที่คุณต้องการจะออมแบบ ก และเงินออมแบบ ข เงินส่วนที่เหลือจะถือว่าเป็นเงินที่ต้องการรับในงวดแรก (ซึ่งเท่ากับ 300 ลบด้วยจำนวนเงินออม) ระบบจะคำนวณเงินที่ได้รับในแต่ละงวดให้คุณ คุณสามารถเลือกแบ่งเงินไปออมทั้ง 2 แบบ หรือแบบใดแบบหนึ่ง หรือไม่ออมเลยก็ได้ แต่ผลรวมของเงินที่จะรับในงวดแรก เงินออมแบบ ก และเงินออมแบบ ข จะต้องเท่ากับ 300 บาท ดอกเบี้ยสำหรับเงินออมแบบ ก และรางวัลสำหรับเงินออมแบบ ข จะแตกต่างกันในแต่ละสถานการณ์ กรุณาตัดสินใจเลือกเงินออมแบบ ก และแบบ ข ในสถานการณ์ A1 ถึง A14 ที่คุณพึงพอใจที่สุด

สถานการณ์ชุด B

สถานการณ์ชุด B ประกอบด้วยสถานการณ์ 10 สถานการณ์ B1 ถึง B10 ในแต่ละสถานการณ์ คุณจะต้องเลือกแบ่งเงิน 300 บาทเป็นสามก้อน ได้แก่ เงินที่จะรับในงวดแรก เงินออมแบบ ก และเงินออมแบบ ค คุณจะได้รับเงินงวดแรกในอีก 2 สัปดาห์ และคุณจะได้รับคุณจะได้รับเงินออมแบบ ก และแบบ ค พร้อมผลตอบแทนในอีก 26 สัปดาห์ เงินออมแบบ ก จะจ่ายดอกเบี้ยแบบเดียวกับสถานการณ์ชุด A ส่วนเงินออมแบบ ค จะไม่จ่ายดอกเบี้ย แต่คุณมีโอกาสที่จะได้รับรางวัลเป็นเงินที่จะได้รับในงวดที่สองพร้อมเงินต้น สิ่งที่เงินออมแบบ ค แตกต่างจากเงินออมแบบ ข ในสถานการณ์ชุด A คือ โอกาสที่คุณจะได้รับรางวัลจะขึ้นอยู่กับจำนวนเงินที่คุณและคนอื่น ๆ ในกลุ่มออมในเงินออมแบบ ค นั่นคือ

คุณจะถูกจับกลุ่มกับผู้เข้าร่วมการทดลองอีก 4 คนแบบสุ่ม เป็นกลุ่มละ 5 คน ผู้เข้าร่วมการทดลอง 1 ใน 5 คนในแต่ละกลุ่ม จะเป็นผู้ได้รับรางวัล นั่นคือ โอกาสที่คุณจะได้รับรางวัลสามารถคำนวณได้จากสัดส่วนเงินออมของคุณต่อเงินออมรวมของทุกคนในกลุ่มของคุณ ทั้งนี้ ผู้เข้าร่วมทดลองแต่ละคนจะไม่ทราบว่ามีใครอยู่ในกลุ่มบ้าง

ตัวอย่างเช่น หากคุณออมเงินแบบ ค เป็นจำนวน 100 บาท และจำนวนเงินออมทั้งหมดของกลุ่มของคุณ (รวมเงินออมของคุณ 100 บาท) เท่ากับ 400 บาท โอกาสที่คุณจะถูกรางวัลจะเท่ากับ 100 ÷ 400 = 0.25 หรือ 25% แต่หากจำนวนเงินออมทั้งหมดของกลุ่มของคุณเท่ากับ 1,000 บาท โอกาสที่คุณจะถูกรางวัลจะเท่ากับ 100 ÷ 1,000 = 0.10 หรือ 10% ทั้งนี้ คุณจะมีโอกาสได้รับรางวัลสูงขึ้น หากคุณออมเงินแบบ ค มากขึ้น ดอกเบี้ยเงินออมแบบ ก และรางวัลสำหรับเงินออมแบบ ค จะแตกต่างกันในแต่ละสถานการณ์ กรุณาตัดสินใจเลือกเงินออมแบบ ก และแบบ ค ในสถานการณ์ B1 ถึง B10 ที่คุณพึงพอใจที่สุด

สถานการณ์ชุด C

สถานการณ์ชุด C ประกอบด้วยสถานการณ์ 10 สถานการณ์ C1 ถึง C10 ในแต่ละสถานการณ์ คุณจะต้องเลือกแบ่งเงิน 300 บาทเป็นสามก้อน ได้แก่ เงินที่จะรับในงวดแรก เงินออมแบบ ก และเงินออมแบบ ง คุณจะได้รับเงินงวดแรกในอีก 2 สัปดาห์ และคุณจะได้รับคุณจะได้รับเงินออมแบบ ก และแบบ ง พร้อมผลตอบแทนในอีก 26 สัปดาห์ เงินออมแบบ ก จะจ่ายดอกเบี้ยแบบเดียวกับสถานการณ์ชุด A ส่วนเงินออมแบบ ง จะไม่จ่ายดอกเบี้ย แต่คุณมีโอกาสที่จะได้รับรางวัลเป็นเงินที่จะได้รับในงวดที่สองพร้อมเงินต้น วิธีการคำนวณโอกาสการได้รับรางวัลจากเงินออมแบบ ง จะเหมือนกับเงินออมแบบ ค ยกเว้นจำนวนคนในกลุ่มในการจับรางวัลจะมี 20 คน ทั้งนี้ คุณจะมีโอกาสได้รับรางวัลสูงขึ้น หากคุณออมเงินแบบ ง มากขึ้น ดอกเบี้ยเงินออมแบบ ก และรางวัลสำหรับเงินออมแบบ ง จะแตกต่างกันในแต่ละสถานการณ์ กรุณาตัดสินใจเลือกเงินออมแบบ ก และแบบ ง ในสถานการณ์ C1 ถึง C10 ที่คุณพึงพอใจที่สุด

สถานการณ์ชุด D

สถานการณ์ชุด D ประกอบด้วยสถานการณ์ 10 สถานการณ์ D1 ถึง D10 ในแต่ละสถานการณ์ คุณจะต้องเลือกแบ่งเงิน 300 บาทเป็นสามก้อน ได้แก่ เงินที่จะรับในงวดแรก เงินออมแบบ ก และเงินออมแบบ จ คุณจะได้รับเงินงวดแรกในอีก 2 สัปดาห์ และคุณจะได้รับคุณจะได้รับเงินออมแบบ ก และแบบ จ พร้อมผลตอบแทนในอีก 26 สัปดาห์ เงินออมแบบ ก จะจ่ายดอกเบี้ยแบบเดียวกับสถานการณ์ชุด

A ส่วนเงินออมแบบ จ จะไม่จ่ายดอกเบี้ย แต่คุณมีโอกาสที่จะได้รับรางวัลเป็นเงินที่จะได้รับในงวดที่สองพร้อมเงินต้น วิธีการคำนวณโอกาสการได้รับรางวัลจากเงินออมแบบ จ จะเหมือนกับเงินออมแบบ ง ในสถานการณ์ชุด C กล่าวคือ โอกาสที่คุณจะได้รับรางวัลขึ้นอยู่กับจำนวนเงินที่คุณและคนอื่น ๆ ออมในบัญชีนี้ และแต่ละกลุ่มประกอบไปด้วย 20 คน แต่จะมีผู้ถูกรางวัลทั้งหมด 4 คนในแต่ละกลุ่ม ทั้งนี้ คุณจะมีโอกาสได้รับรางวัลสูงขึ้น หากคุณออมเงินแบบ จ มากขึ้น ดอกเบี้ยเงินออมแบบ ก และรางวัลสำหรับเงินออมแบบ จ จะแตกต่างกันในแต่ละสถานการณ์ กรุณาตัดสินใจเลือกเงินออมแบบ ก และแบบ จ ในสถานการณ์ D1 ถึง D10 ที่คุณพึงพอใจที่สุด

สถานการณ์ชุด E

สถานการณ์ชุด E ประกอบด้วยสถานการณ์ 5 สถานการณ์ E1 ถึง E5 ในแต่ละสถานการณ์ คุณจะต้องเลือกแบ่งเงิน 300 บาทเป็นสองก้อน ได้แก่ เงินที่จะรับในงวดแรก และเงินออมแบบ ก ซึ่งจะได้รับในงวดที่สอง คุณจะได้รับเงินงวดแรกในอีก 2 สัปดาห์ และคุณจะได้รับเงินออมพร้อมดอกเบี้ยในอีก 26 สัปดาห์ เงินออมแบบ ก จะจ่ายดอกเบี้ยแบบเดียวกับสถานการณ์ชุด A กรุณาตัดสินใจเลือกจำนวนเงินออมแบบ ก ในสถานการณ์ E1 ถึง E5 ที่คุณพึงพอใจที่สุด

7.3 Survey Questions

1. อายุ:
2. เพศ:
3. คณะ:
4. ชั้นปี:
5. ในสถานการณ์ชุด A คุณมีวิธีการในการแบ่งเงินที่คุณจะได้รับในอีก 2 สัปดาห์ หรือ 10 สัปดาห์อย่างไร
6. คุณมีความคิดเห็นอย่างไรกับวิธีการออมเงินซึ่งไม่จ่ายดอกเบี้ย แต่ได้รับโอกาสที่จะถูกรางวัลใหญ่แทน
7. เปรียบเทียบระหว่างเงินออมที่ไม่จ่ายดอกเบี้ย คุณชอบแบบ ข ซึ่งคุณจะทราบโอกาสที่ถูกรางวัล หรือ แบบ ค ง จ ซึ่งคุณจะทราบว่าจะต้องมีคนในกลุ่มถูกรางวัลอย่างแน่นอน มากกว่ากัน เพราะอะไร
8. เปรียบเทียบระหว่างการออมแบบ ค ซึ่งมีผู้ถูกรางวัลเล็ก 1 คน จาก 5 คน กับแบบ ง ซึ่งมีผู้ถูกรางวัลใหญ่ 1 คน จาก 20 คน คุณชอบแบบใดมากกว่ากัน เพราะอะไร
9. เปรียบเทียบระหว่างการออมแบบ ง ซึ่งมีผู้ถูกรางวัลใหญ่ 1 คน กับ แบบ จ ซึ่งมีผู้ถูกรางวัลเล็ก 4 คน จากจำนวน 20 คน เท่ากัน คุณชอบแบบใดมากกว่ากัน เพราะอะไร
10. คุณออมเงินเป็นจำนวนร้อยละเท่าใดของรายได้หรือเงินเดือน
11. ยอดเงินรวมของคุณในทุกบัญชี ณ วันสุดท้ายของเดือนที่แล้วเป็นเท่าไร
12. คุณเคยซื้อสลากออมสินหรือสลาก ธกส. หรือไม่
13. ปัจจุบันคุณมีสลากออมสินหรือสลาก ธกส. ที่ยังไม่ครบกำหนดถอนหรือไม่
14. คุณซื้อลอตเตอรี่บ่อยเพียงใด (ก) ทุกงวด (ข) ทุกเดือน (ค) ไม่กี่ครั้งต่อปี (ง) นาน ๆ ครั้ง (จ) ไม่เคยซื้อ
15. คุณเล่นการพนัน เช่น พนันฟุตบอล ไพ่ คาสิโนบ่อยเพียงใด (ก) ทุกอาทิตย์ (ข) ทุกเดือน (ค) ไม่กี่ครั้งต่อปี (ง) นาน ๆ ครั้ง (จ) ไม่เคยเล่นการพนัน

Cognitive reflection test

16. ไม้เทนนิสและลูกเทนนิสราคารวมกัน 110 บาท ไม้เทนนิสราคามากกว่าลูกเทนนิส 100 บาท ลูกเทนนิสราคาเท่าใด
17. ถ้าเครื่องจักร 5 เครื่องใช้เวลา 5 นาทีในการผลิตสินค้า 5 ชิ้น เครื่องจักร 100 เครื่องจะใช้เวลากี่นาทีในการผลิตสินค้า 100 ชิ้น
18. มีใบบัวอยู่ในบึง ในแต่ละวัน ปริมาณของใบบัวจะเพิ่มขึ้นเป็นเท่าตัว ถ้าใบบัวปกคลุมบึงทั้งบึงในเวลา 48 วัน ใบบัวจะใช้เวลากี่วันในการปกคลุมบึงครึ่งหนึ่ง