A MICROSOFT EXCEL® TEMPLATE FOR TEACHING ABOUT BANK RUNS OR RUNNING BANK RUN EXPERIMENTS

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ABSTRACT

In this paper we describe a Microsoft Excel® template useful for instructors wishing to show students the incentives faced by bank depositors who suspect that their bank is in danger of becoming illiquid or insolvent, or wishing to play the run-on-the-bank game in class. The template is very flexible allowing for anywhere between two to ten bank customers, variable rates of return on bank investments, and lending rates. The template allows instructors to simulate traditional as well as silent bank runs, both of which are especially relevant to today's students in view of the recent financial crisis.

INTRODUCTION

A scene in Frank Capra's 1946 movie It's a Wonderful Life depicts a classic run on a depression-era bank. In the movie, financial panic has engulfed Bedford Falls, and George Bailey, portrayed by Jimmy Stewart, through a series of events finds himself at the helm of Bailey Building and Loan, the smaller of two financial institutions in the town. Though George Bailey represents the archetypal conscientious banker, events have cast doubt on the bank's ability to make good on deposits. The bank depositors, fearing impending insolvency and worried about their own financial difficulties arrive in masse to demand their deposits. In a dramatic scene, George narrowly avoids ruin by making a personal appeal to each customer in an attempt to regain the depositors' trust and to avoid a total collapse of the bank. Though the story dramatizes how clean living and a sense of community can help avert a bank run, the reality is that, without outside assurances (e.g., deposit insurance), once a run starts, it tends to be self-perpetuating, and continues until the bank is insolvent.

During the depression-era bank runs, those who were slow to demand their deposits often ended up losing them entirely. Today's economics students who are accustomed to federally insured bank accounts may recognize the drama of the bank run scene, but may not fully comprehend the reasoning behind the characters' actions. Possibly the best way to explain a bank run and reasoning behind policies intended to avert them to students is to put the students into the shoes of the Bailey's Building and Loan depositors, forcing them to decide whether or not to withdraw their money.

Because there are certain well-defined rules governing how banks and depositors interact, researchers have sought to better understand the dynamics of bank runs through economic experiments. For example, banks generally honor withdrawal
requests on a first-come-first-serve basis. As a result of this practice, it is usually in the
best interest of depositors who suspect that their bank is illiquid to rush to withdraw
their money whenever they think their bank is unstable and that other depositors will do
the same. The incentives to withdraw deposits from troubled banks (or even those
rumored to be troubled) are mitigated when, for example, deposits are insured, or when
there is a lender of last resort willing to lend funds to illiquid but solvent institutions, or
even when insolvent “too-large-to-fail” institutions have shown that they can access
funding through emergency government action. Given any or all of the aforementioned
scenarios, depositor incentives and actions can be modeled and observed using a run-
on-the-bank game. The chief benefit of the game is that it allows researchers to
incorporate different banking policies in an experimental setting to gauge their effects of
the depositor, and consequentially on the overall economy. Originally published by
Bryant (1980), Diamond and Dybvig (1983), and Jacklin and Bhattacharya (1988), the
game has been adapted to be a more undergraduate-friendly presentation by Gibbons
(1992), and further modified into a hands-on learning experience by Balkenborg, Kaplan
and Miller (2011), who developed an experiment that can be performed in class or
online¹.

In this paper, we develop a Microsoft Excel® template useful to those instructors
wishing to show the above described banking behaviors to students using a numeric
eexample, or those wishing to play the run-on-the-bank game in a classroom setting. The
template allows instructors to play the already well-known game with as few as two
players or with as many players as are present, to modify rates of return, lending rates,
and the existence of deposit insurance or the existence of a lender of last resort. This
classroom activity is particularly relevant in today’s economy given the recent financial
crisis, and all the changes it has led to and will lead to in terms of banking and financial
regulations.

Using interactive teaching techniques, classroom activities, and classroom
experiments is a fun way to motivate students to learn. This is especially important for
instructors dealing with topics that are abstract and technical. Experiments and games
can provide a link between formal theories and real life economic situations and guide
students toward self-discovery of complex theories (Holt 1999 and 2003). Furthermore,
since by participating in experiments students gain real life-like experience, student
participation in classroom discussions and the quality of participation can improve after
games and experiments are played in class (see e.g., Holt 1999 and 2003, and
Balkenborg and Kaplan 2009). Finally, students are likely to perform better in tests and
courses when instructors include interactive techniques in their courses (Emerson and
Taylor 2004, Ball, Eckel and Rojas 2006, Dickie 2006, Durham, McKinnon and
Schulman 2007).

The remainder of this paper is organized as follows: First, we review the basic
run-on-the-bank game using a simple numerical example. We then develop an
alternative to the game in which a bank facing the crisis can borrow funds as needed at a
stated interest rate. We then describe the Excel® template and discuss how it can be
used in a classroom setting. Finally we conclude and discuss avenues for future work.

BASIC GAME

Consider the following simple version of the basic bank-run game: two investors, A and B, deposit $100 each in non-transaction bank accounts\(^2\). The bank uses these funds to make a $200 two-year loan\(^3\). At the end of year two, when the loan matures, the bank collects a 10% rate of return (a payoff of $220). However, if the bank has to recall the loan or sell it at the end of year 1 before it matures the bank is only able to recover $160.

Investors A and B may withdraw their money at any time. If both investors wait until the end of the second year to withdraw their funds they each get a payoff of $110\(^4\). If one of the investors withdraws his funds before the loan matures he gets a $100 payoff while the second investor only recovers $60. If both investors try to withdraw their money on the first year only the investor who reaches the bank first gets $100; the investor who gets there last only receives $60.\(^5\)

Each investor has two strategies: to withdraw his money on year 1 or to wait and withdraw the money on the second year. Assuming that the time discount parameter is zero we can summarize the expected discounted payoffs of the game in year 1 using the following matrix. Within each cell, the first value denotes the payoff of investor A, while the second value denotes the payoff of investor B. For example, if investor A plays “Withdraw at t=1” while Investor B plays the “Not Withdraw at t=1” strategy, investor A’s payoff is $100 while B’s payoff is $60.

<table>
<thead>
<tr>
<th>Investor B</th>
<th>Withdraw At t =1</th>
<th>Not Withdraw At t =1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investor A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Withdraw at t =1</td>
<td>$60, $100 if investor B reaches bank first or $100, $60 if investor A</td>
<td>$100, $60</td>
</tr>
<tr>
<td>Not Withdraw at t =1</td>
<td>$60, $100</td>
<td>$110, $110</td>
</tr>
</tbody>
</table>

This game has two Nash equilibria (shaded) in pure strategies: (withdraw, withdraw) and (not withdraw, not withdraw). The equilibrium in which both investors withdraw their deposits in period 1 is known as a run on the bank. While this is an inferior equilibrium, it is the best strategy for any investor who expects the other investor to withdraw his funds on the first period.

In general, let \( r \) denote the interest rate charged by the bank on the loan (or the rate of return on the bank’s investment) and let \( p \) denote the proportion of the original...
loan (investment) recovered if it is recalled (or sold) before it matures. Then, if both investors wait until the end of the second period to withdraw their funds they each get:

\[
\frac{200(1 + r)}{2} = 100(1 + r)
\]

However, if one investor withdraws money in period 1 while the other does not, or if both try to withdraw money in the first period the first investor to withdraw money receives $100. The second investor receives the amount that is left after the loan (investment) is recalled (sold) and the first investor has been paid:

\[
200 p - 100 = 100(2p - 1)
\]

**LENDER OF LAST RESORT**

Assume now that there is some entity, a central bank or other banks, willing to lend the bank as much money as needed in period 1 at an interest of \(i\). As a result, if one or both investors want to withdraw their funds before the investment matures the bank can borrow enough money to honor the withdrawals without having to liquidate its assets.

Once more, each investor has two strategies: to withdraw his money in period 1 or to wait and withdraw the money at the end of the second period. Assuming that the bank pays an interest of 10% on borrowed funds we can summarize the payoffs of the game using the following matrix:

<table>
<thead>
<tr>
<th></th>
<th>Investor B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Investor A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Withdraw at (t = 1)</td>
<td>$100, $100</td>
<td>$100, $110</td>
</tr>
<tr>
<td>Not Withdraw at (t = 1)</td>
<td>$110, $100</td>
<td>$110, $110</td>
</tr>
</tbody>
</table>

If both investors withdraw money the bank borrows $200 and gives $100 to each investor. At the end of period 2 the bank uses the proceeds from the investment ($220) to pay off the loan. If one investor withdraws in period 1, the bank borrows $100 to honor the withdrawal. At the end of period 2 the bank collects $220 which it uses to pay off the loan ($110) and the other investor ($110). Finally, if both investors wait until the end of period 2 they each get $110.
The game now has a unique Nash equilibrium (shaded) in which both investors are better off waiting to withdraw their money in the second period, regardless of what the other investor does. The presence of a lender of last resort in the game eliminates the run-on-the-bank equilibrium.\textsuperscript{6}

In general, letting $i$ denote the interest rate paid by the bank on any borrowed funds, then if both investors wait until the end of the second period to withdraw their funds they each get a payoff of:

$$\frac{200(1 + r)}{2} = 100(1 + r)$$

However, if at least one investor tries to withdraw money in the first period, then the first investor to make it to the bank gets $100 while the other investor receives what is left of the future value of the investment after the bank pays the principal and interest on the loan:

$$200(1 + r) - 100(1 + i) = 100(1 + 2r - i)$$

\textbf{A GAME WITH N PLAYERS}

The game described above only applies to two players (or investors). However in order for the game to be useful in a classroom setting instructors should be able to adapt the rules and the payoffs of the game to more than two players. In this section we describe the payoffs of the game when there are $n$ players. As in the previous examples, we assume that each of the $n$ players deposits $100 in the bank in period 1. Furthermore, we assume that $r$ denotes the rate of return on the bank’s investment, and $p$ represents the proportion of the original investment recovered if the investment is recalled or sold before it matures, and $i$ denotes the interest rate paid by the bank on any deposited (i.e., invested) funds.

The formulas used to calculate the payoffs are as follows: If no one withdraws money in period 1, each player gets the future value of its investment $FV$:

$$FV = \frac{100n(1 + r)}{n} = 100(1 + r)$$

If at least one person withdraws money before the investment matures and there is no “lender of last resort” only the first few investors get their $100 back. Those who arrive too late get $0 or share the amount left in the bank equally. More specifically, let $CV$ denote the total number of investors who would be able to withdraw money in period 1 before the investment matures:

$$CV = 100n \frac{p}{100} = np$$
If the number of investors trying to withdraw funds in period 1, denoted by \( x \), is no larger than \( CV \), all those who want to withdraw money receive $100; therefore, the payoff to the other investors depends on the presence of a lender of last resort (i.e., another lender willing to lend the insolvent bank the necessary funds). If there is no lender of last resort, all other investors split equally the amount left from the recalled loan, \( FC \):

\[
FC = \frac{100nP - 100x}{n - x}
\]

If there is a lender of last resort, however, they split equally the future value of the investment minus the payment of the loan (principal plus interest), \( FA \):

\[
FA = \frac{100n(1 + r) - 100x(1 + i)}{n - x}
\]

Finally, if the total number of investors who want to withdraw funds in period 1 is larger than \( CV \), and there is no lender of last resort, then only the first \( CV \) investors receive $100. The remaining investors (depositors) get $0. If there is a lender of last resort, the first \( CV \) investors would receive $100, while all other investors would split equally the future value of the investment minus the payment of the loan, \( FB \):

\[
FB = \frac{100n(1 + r) - 100 CV (1 + i)}{n - CV}
\]

These payoffs are summarized in Figure 1.

**A MICROSOFT EXCEL® TEMPLATE**

In this section we describe a Microsoft Excel® template that summarizes the payoffs of the game described above. We first describe the Excel® template when only two players are involved. We then extend the file to allow for ten players. The actual number of players is up to the instructor. The Excel® file can be modified to accommodate as many players as needed.

**Two players**

The excel document has two worksheets. The first sheet contains the three parameters that the instructor needs to choose before the game begins: the rate of return on the investment \( r \), the percentage of the original investment that is recovered if it is canceled before it matures \( p \), and the interest rate charged to the bank if it needs to borrow money \( i \). If the instructor does not want to allow for a lender of last resort feature in the game this last interest should be left blank. Figure 2 shows the Excel® spreadsheet in which the rate of return on the investment is 10%, the penalty for canceling an investment early or before it matures is 20%, and in which it is not possible for the bank to borrow money.
**FIGURE 1: SUMMARY OF PAYOFFS**

For $x=$ Number of players withdrawing funds in period 1, the payoffs are as follows:

<table>
<thead>
<tr>
<th>$x=0$</th>
<th>All players get</th>
<th>Payoffs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$FV = 100 \times (1 + r)$</td>
<td></td>
</tr>
</tbody>
</table>

For $0 < x \leq CV$:

<table>
<thead>
<tr>
<th>First CV players get</th>
<th>Payoffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>No lender of last resort</td>
<td>$100$</td>
</tr>
<tr>
<td>Last $n$-CV players get</td>
<td>$FC = \frac{100 \times n \times p - 100 \times x}{n-x}$</td>
</tr>
</tbody>
</table>

For $CV < x \leq n$:

<table>
<thead>
<tr>
<th>First CV players get</th>
<th>Payoffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>No lender of last resort</td>
<td>$100$</td>
</tr>
<tr>
<td>Last $n$-CV players get</td>
<td>$FB = \frac{100 \times n \times (1+r) - 100 \times CV \times (1+i)}{n-CV}$</td>
</tr>
</tbody>
</table>
FIGURE 2:
PARAMETERS SET BY INSTRUCTOR

- Interest Rate Charged to the Bank on Loan (e.g., Fed Funds Rate or Discount Rate)
- Percentage of the Original Investment Recovered if Investment is Sold before Maturity: 80.00%
- Rate of Return on Investment if Held until Maturity: 10.00%

FIGURE 3:
BASIC SET UP

<table>
<thead>
<tr>
<th>Start of the Game</th>
<th>Order of Period 1 Withdrawal</th>
<th>Payoffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investor #1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Investor #2</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Check to reveal payoffs
Figure 3 shows the spreadsheet with the deposits, withdrawal activity, and payoffs of the game. The instructor can use this spreadsheet for himself or herself to aid in the calculation of payoffs alone, or to display to the students to reveal the outcomes of the game. Figure 3 only shows the case in which the two deposits have been made.

**FIGURE 4: NO WITHDRAWALS**

![Figure 4: No Withdrawals](image1)

**FIGURE 5: ONE WITHDRAWAL**

![Figure 5: One Withdrawal](image2)
FIGURE 6:
TWO WITHDRAWALS

If neither student withdraws money in the first period the instructor only needs to check the box that reveals the second period payoffs. Both players get $110. This case is presented in Figure 4. If only one student withdraws money, the instructor should place the number 1 next to that student under the “withdrawal activity” column. Since the other student does not withdraw money the cell next to him/her under the withdrawal activity should be left blank. By clicking on the check box the instructor can reveal the second period payoffs. Player 1 gets $100 and player 2 gets $60. This case is presented in Figure 5. Finally, Figure 6 shows the outcome in which both players try to withdraw money in the first period. It is assumed that student # 2 reaches the bank first. Clicking on the checkbox reveals that this student gets $100 while player 1 gets $60.

If the instructor wants to allow a lender of last resort, the instructor needs to specify the rate at which the bank will be able to borrow money in the first spreadsheet. Figure 7 shows the choice of parameters assuming that the bank is able to borrow money at a 10% interest rate. Figures 8 through 10 calculate the payoffs under this scenario when both players wait until the end of the second period to withdraw funds (Figure 8), when only player # 1 withdraws money in the first period (Figure 9), and when both players withdraw money in the first period (Figure 10). Finally, Figure 11 reveals the formulas behind the Excel® Spreadsheets.
FIGURE 7:
PARAMETERS SET BY INSTRUCTOR WITH A LENDER OF LAST RESORT

![Excel sheet showing parameters for a bank loan and investment recovery rates.]

FIGURE 8:
NO WITHDRAWALS WITH LENDER OF LAST RESORT

![Excel sheet showing investment period with no withdrawals and fixed payoffs.]

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Ten players

In this section we describe an Excel® spreadsheet that extends the basic game described above to ten players. Instructors can change the number of players by inserting or deleting rows and adjusting the formulas. The Excel® document has two worksheets. The first screen looks exactly as the screen depicted in Figure 2. In it, the instructor chooses the basic parameters of the game. The second spreadsheet contains the formulas needed to do the calculations of the experiment. It initially includes the list of players or investors (column A) and the original deposits (column B). Column C has room for the instructor to list the order in which players withdraw their investment in
period 1. This column should be left blank whenever a player does not attempt to withdraw funds in the first period. Lastly, column D shows the payoffs of the game.

FIGURE 11: EXCEL® FORMULAS

The worksheet has a checkbox in cell B14. When checked, the payoffs are revealed. If unchecked the payoffs’ column remains blank. There are some calculations in columns F through J that are “hidden” from view (white font on white background). These columns are included in the file to make the formulas in the payoff column easier to track. Figure 12 shows how the spreadsheet looks when those columns are hidden and before the game is played, while Figure 13 also reveals the hidden columns. Figure 14 shows the payoffs of the game when no players withdraw money in period 1; Figure 15 shows the payoffs when four players withdraw money in period 1 and the bank cannot borrow funds, while Figure 16 shows the outcome when the bank is able to borrow funds at a 10% interest rate. The formulas used to calculate the payoffs of this game are as described in section 4 for \( n=10 \). These are specified as a set of “IF” statements in Excel®. All of the formulas and statements used in the Excel® document are listed in the Appendix.
FIGURE 12:
START OF GAME WITH TEN PLAYERS

<table>
<thead>
<tr>
<th>Period</th>
<th>Start of the Game</th>
<th>Order of Period 1 Withdrawals</th>
<th>Payoffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investor #1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #2</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #3</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #4</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #5</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #6</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #7</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #8</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #9</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor #10</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Deposits</td>
<td>1000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 13:
START OF GAME WITH TEN PLAYERS (HIDDEN COLUMNS REVEALED)
FIGURE 14:
OUTCOME OF 10-PLAYER GAME WHEN ALL INVESTORS WAIT UNTIL PERIOD 2 TO WITHDRAW FUNDS

<table>
<thead>
<tr>
<th>Period</th>
<th>Start of the Game</th>
<th>Order of Period 1 Withdrawals</th>
<th>Payoffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Investor #1</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>4</td>
<td>Investor #2</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>5</td>
<td>Investor #3</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>6</td>
<td>Investor #4</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>Investor #5</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>8</td>
<td>Investor #6</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>9</td>
<td>Investor #7</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>10</td>
<td>Investor #8</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>11</td>
<td>Investor #9</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>12</td>
<td>Investor #10</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>13</td>
<td>Total Deposits</td>
<td>1000</td>
<td>1100</td>
</tr>
</tbody>
</table>

FIGURE 15:
OUTCOME OF 10-PLAYER GAME WHEN SOME INVESTORS WAIT UNTIL PERIOD 2 TO WITHDRAW FUNDS AND THERE IS NO LENDER OF LAST RESORT

<table>
<thead>
<tr>
<th>Period</th>
<th>Start of the Game</th>
<th>Order of Period 1 Withdrawals</th>
<th>Payoffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Investor #1</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Investor #2</td>
<td>100</td>
<td>66.6666667</td>
</tr>
<tr>
<td>5</td>
<td>Investor #3</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Investor #4</td>
<td>100</td>
<td>66.6666667</td>
</tr>
<tr>
<td>7</td>
<td>Investor #5</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>Investor #6</td>
<td>100</td>
<td>66.6666667</td>
</tr>
<tr>
<td>9</td>
<td>Investor #7</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>Investor #8</td>
<td>100</td>
<td>66.6666667</td>
</tr>
<tr>
<td>11</td>
<td>Investor #9</td>
<td>100</td>
<td>66.6666667</td>
</tr>
<tr>
<td>12</td>
<td>Investor #10</td>
<td>100</td>
<td>66.6666667</td>
</tr>
<tr>
<td>13</td>
<td>Total Deposits</td>
<td>1000</td>
<td>800</td>
</tr>
</tbody>
</table>
FIGURE 16:
OUTCOME OF 10-PLAYER GAME WHEN SOME INVESTORS WAIT UNTIL PERIOD 2 TO WITHDRAW FUNDS AND THERE IS A LENDER OF LAST RESORT

SOME SUGGESTIONS ON HOW TO USE THE SPREADSHEET IN CLASS

There are different times during which an instructor may wish to introduce the activity to the class. We suggest using the game when discussing the tools of monetary policy and the roles of central banks as lenders of last resort, the incentives created by “too big to fail” financial institutions, shadow banking, the history the US financial system or financial regulations, or the recent financial crisis. While these topics are typically covered in money and banking courses, the activity is simple and intuitive enough that can be introduced at any level, from principles of macroeconomics to upper level macroeconomics and money and banking courses. Furthermore, and following recommendations from Holt (1999 and 2003) to “lead students to self-discover[y]”, we believe that it is best to use the activity or play the game before lecturing students on bank runs, lenders of last resort, or the existence of deposit insurance.

In this section we describe two ways in which we have used the Excel ® template in our courses: we have incorporated the template into regular Power Point lectures and into classroom experiments.

After describing the basic setting from previous sections the instructor can display the spreadsheet on a projector screen. The instructor can choose ten students in the class or can ask for volunteers to be the ten account holders. The students who are selected have to be told to let the instructor know (by raising hands or speaking out loud) when they want to withdraw their money. Instructors can use the spreadsheet to
show students how their bank account balances are affected when one or more depositors try to withdraw funds before bank investments mature. The instructor can begin by coaxing one account holder to withdraw his or her money, and then another, and another, and so on. Some students will chime in unsolicited and ask to withdraw their funds as well. By showing how balances change as one, two, three, and more depositors withdraw funds students will see the incentives that lead to runs on banks. Assuming no lender of last resort, at some point all students will be clamoring to get their money back. Student behavior should be the opposite when the instructor announces that there is a lender of last resort. Even if the instructor can persuade some students to withdraw money, no unsolicited withdrawals should take place.

Alternatively, instructors can choose to play the traditional run-on-the-bank game and use the spreadsheet to calculate end of period payoffs. There is not just one way to play the game. Balkenborg et al. (2011) for example describe a version of the game and discuss instructions to play their game in a classroom and online setting. Since our contribution is the development of the spreadsheet in this section we highlight how instructors can incorporate it in a classroom game or lecture.

If playing the ten player version, students need to be divided in ten groups. Each group is given a withdrawal/coupon book in which students can record the intention to withdraw funds at the end of period 1, and in which instructors can record the group’s end of period balance. Figure 17 shows a slip we have actually used in our courses.

**FIGURE 17: WITHDRAWAL BOOKLET**

<table>
<thead>
<tr>
<th>DATE</th>
<th>BALANCE</th>
<th>WITHDRAW?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$100</td>
<td>YES   NO</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Students are told that they begin the game in period one with $100 in deposits. The bank collects a total of $1,000 and invests the money at a rate of return predetermined by the instructor. Students are also told that the investment is risky, and that there is a probability that the issuer of the bond bought by the bank will default. During the first period the instructor can flash a slide with more information about the
bond issuer. The first time the game is played the instructor can give reassuring news that the bond issuer is in excellent financial shape and is highly unlikely to default. Students are then instructed to make a decision to either withdraw the money at the end of period 1 or wait until period 2. All students are told to check the “yes” or “no” withdrawal box in their coupon book and to walk up to the front of the room to turn in their slips. The instructor has to keep track of the order in which slips are turned in and has to record which group asked to withdraw funds and in which order. If the instructor has access to clickers students can alternatively be asked to record their choices using these. Since clickers are registered to individual students, and since instructors can see in their computer screens student clicker choices “live”, using these eliminates the need to collect the withdrawal slips. It also makes the student choices more secretive making it more difficult for students to predict what other players will do.

At this point the instructor can use the spreadsheet to quickly calculate and let each group know their ending balance. If the instructor wishes to keep information private he/she can simply return slips to each group with their ending balance filled in. However, if the instructor wants to reveal which group withdrew funds, he/she can display the complete spreadsheet to the class.

The game can be replayed as many times as the instructor wishes. In a second round the instructor can change the odds that the bond issuer will default or the existence of deposit insurance, depending on the outcomes of the first round.

There are important characteristics of the banking system that are not included in this game. For example, the deposits are limited to non-transaction deposits which eliminate the need for the bank to hold required reserves. The game does not allow the bank to make a profit, it does not allow investors to make partial withdrawals, and it assumes that the time discount parameter is zero. The instructor can actually address these issues after playing the game or discussing the activity in class. For example, introducing a required reserve ratio would change the payoffs of the game slightly but would not affect the basic incentives of the players. Discussing transaction deposits and non-transaction deposits can lead to a discussion of reserve accounting, and the tools used by banks to minimize the amount of required reserves they have to hold. Similarly, allowing the bank to retain some of the return on the investment would scale down the payoffs to investors but would not change their incentives to withdraw or keep the money in the bank until the game ends. It might, however, change the type of investment that banks undertake.

**FINAL REMARKS**

Having a ‘George Bailey’ at the helm of the bank where you keep your life’s savings might inspire confidence in the institution; it may even reduce the chances of a run on the bank during a period of financial turbulence; however, even with the conscientious and prudent leadership that only Jimmy Stewart can dramatically provide, only 2 dollars kept the romanticized Bailey Building and Loan from insolvency during the run on the bank. In the climactic scene of the movie, George, facing financial ruin and arrest because of Uncle Billy’s accidental loss of a large sum of the bank’s
money, finds himself being rescued by his depositors on Christmas Eve. What makes this scene all the more dramatic is George’s realization that the depositors are acting in opposition to their economic incentives by bailing him out. Furthermore, had it not been for the intervention of higher powers, events would have turned out much worse for George and Bailey Building and Loan. Though Hollywood rarely lets reality interfere with the making of a good movie, it is important for business and economic students to understand the underlying incentives faced by depositors under different types of banking regimes, and their results in the financial world. Judging from the concern he displayed over his own situation, George Bailey understood the account-holder’s incentives and was at the very least surprised when they decided as a group to act otherwise.

In this paper we present a variation of the run-on-the-bank game and provide detailed information on the construction of an Excel® spreadsheet that instructors can use to describe banking behaviors in class. Our spreadsheet is meant to aid the instructor in calculations and presentation of results, allowing the instructor to focus his or her attention on more critical areas of instruction.

ENDNOTES

1. The online experiment can be found at http://projects.exeter.ac.uk/feele/ExperimentList.shtml#DiamondDyvbig
2. The basic game assumes that deposits are made to non-transaction accounts, which eliminates the need for a reserve requirement. While we do have such requirements in our economy, the reality is that there are many ways in which banks can minimize the amount they keep in required reserves from transaction deposits.
3. Alternatively, the bank can buy a two-year-bond or any other financial instrument with a two-year maturity.
4. We assume, for simplicity, that the bank is liquidated at the end of the second year and assets are distributed equally among depositors. Students might wonder why banks do not make a profit or have a mechanism for generating a profit. This is a simplification of the game in line with the extant literature. However, it would not be difficult to restrict the rate of return to investors to a lower value and to allow banks to retain some of their profits. For example, in the basic example, it is possible to assume that the rate of return to the bank is 10% but to investors is only 9%. The basic incentives and equilibrium of the game should not change. This is something that can be discussed with students.
5. A similar example can be found in Gibbons (1992). The main difference between our presentation and Gibbons is that he assumes that if both investors try to withdraw their money in period 1 they split the $160 evenly.
6. As long as the interest charged to the bank on the loan is less than twice the rate of return on the investment the game has a unique Nash equilibrium in which both players wait until the end of the second period to withdraw their money.

REFERENCES


**APPENDIX: N-PLAYER SPREADSHEET FORMULAS**

For every cell Dk, where k=3 through 12, the formula is:

=IF($B$15,IF($C$1=0,Jk,IF($C$1<=Ik,Bk,IF("Parameters Set by Instructor!"$A$2>0,Fk,Hk)),IF(ISBLANK(Ck),IF("Parameters Set by Instructor!"$A$2>0,Gk,0),IF(Ck<=Ik,Bk,IF("Parameters Set by Instructor!"$A$2>0,Gk,0)))),""")
For every cell $F_k$, where $k=3$ through 12, the formula is:

$$=(B13*(1+'Parameters Set by Instructor'!A6)-B_k*C1*(1+'Parameters Set by Instructor'!A2))/(C1)$$

For every cell $G_k$, where $k=3$ through 12, the formula is:

$$=(B13*(1+'Parameters Set by Instructor'!A6)-(B_k*I_k)*(1+'Parameters Set by Instructor'!A2))/(I_k)$$

For every cell $H_k$, where $k=3$ through 12, the formula is:

$$=(B13*'Parameters Set by Instructor'!A4-B_k*C1)/(C1)$$

For every cell $I_k$, where $k=3$ through 12, the formula is:

$$=B13*'Parameters Set by Instructor'!A4/100$$

For every cell $J_k$, where $k=3$ through 12, the formula is:

$$=B13*(1+'Parameters Set by Instructor'!A6)/10$$

Cell $C1$ is given by:

$$=COUNT(C3:C12)$$

Cell $B13$ is given by:

$$=SUM(B3:B12)$$

Cell $D13$ is given by:

$$=IF(B15,SUM(D3:D12), "")$$