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Technology Adoption in the Presence of Network Externalities: A Web-Based Classroom Game

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Abstract

This paper describes a customizable classroom game used to demonstrate the effects of network externalities on the adoption of new technologies. The game is a web-based adaptation of Ruebeck et al.'s (2003) network externalities game. The web-based game is freely available and can be played in a networked lab setting or via the Internet. In this game, players choose one of a number of competing technologies whose utility depends on the number of others choosing the same technology. In subsequent variations, we introduce sequential choice, imperfect information, heterogeneity, "lock-in", and switching costs.

Editor's note: This is a pdf copy of an html document which resides at <http://ite.pubs.informs.org/Vo8No1/WolfPortegys/> (Volume 8, Number 1, September 2007)

1. Introduction

Extant literature suggests that network externalities can result in the dominance of one technology even if it is inferior to an alternate technology. As Ruebeck, Stafford, Tynan, Alpert, Ball, and Butkevich (2003) note, network externalities exist when the value of a product or service to a consumer depends on the number of other people using a compatible product or service. Katz and Shapiro (1985) noted that these externalities may be direct or indirect. Direct network effects are benefits generated through a direct physical effect of the number of users on the value of a product or service. For example, MSN Messenger users can only send instant messages to others using MSN Messenger software. As a result, each additional MSN Messenger user directly and positively affects the value of the product. With indirect network effects, consumption benefits do not depend directly on the number of users but are "market mediated." For example, as more users adopt the Linux computer operating system more software developers will start to produce Linux versions of their products.

The goal of this paper is to describe a customizable web-based classroom game used to demonstrate the effects of network externalities on the adoption of new technologies. The game is a web-based adaptation of Ruebeck et al.'s (2003) network externalities game. In our web-based adaptation, players choose one of a number of competing technologies whose utility depends on the number of others choosing the same technology. In subsequent variations, we introduce sequential choice, imperfect information, heterogeneity, "lock-in", and switching costs. The game is freely available and can be played in a networked lab setting or via the Internet.

2. Obtaining and Installing the Software

The Game Master application, which can be downloaded from here⁽¹⁾, requires a recent version of Java, e.g. 1.4 or higher, available at java.sun.com.⁽²⁾

The *jar* file contains all the source code, associated files, build command, HTML files, and the Master executable code. The Game Master can be started on most Windows systems by simply double-clicking the *jar* file; otherwise, entering the following command from the command line will also start it:

java -jar GameMaster.jar

The source files, which are compressed, are unpacked from the *jar* file with the *jar* tool that comes with Java, or with an archiving tool such as *WinRAR*, available at RARLAB⁽³⁾. The system is then built by executing the *buildgame.bat* file, and tested with the *rungame.bat* file.

The Game Player is a signed Java applet that will run in most browsers including Internet Explorer, Firefox and Mozilla. The Game Player is available here⁽⁴⁾

To install the Player applet on a specific web server, copy the *gameplayer.html* (included in the *jar* file), and *GamePlayer.jar* files to that server. The *MasterHost* parameter in *gameplayer.html* can be set to the IP address of the Master host, which will allow players to connect to it. The Player applet communicates with the Master via Java RMI (Remote Method Invocation) necessitating the signing of the applet with the *jarsigner* command, which is invoked from the *buildgame.bat* script. The *jarsigner* command expects to find a public/private key pair on the computer where the game is installed having the alias "ugame". This can be created with the *keytool* command as follows:

keytool -genkey -alias ugame -keypass your_password

Upon connecting to the Master, you may be prompted to unblock a network connection to allow RMI to proceed.

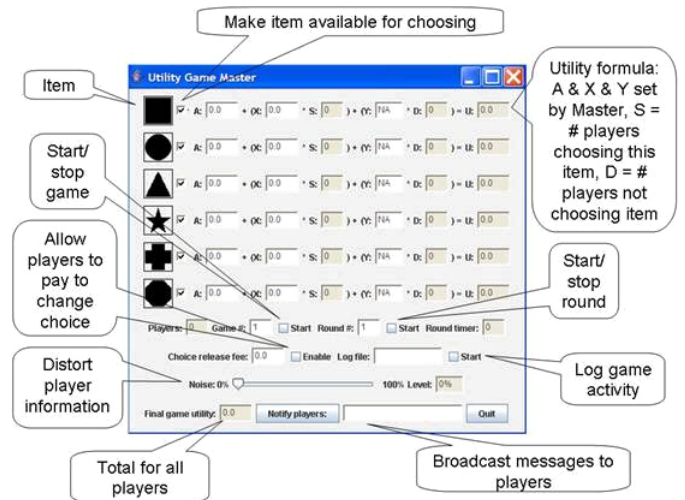


Figure 1: Game Master Application.

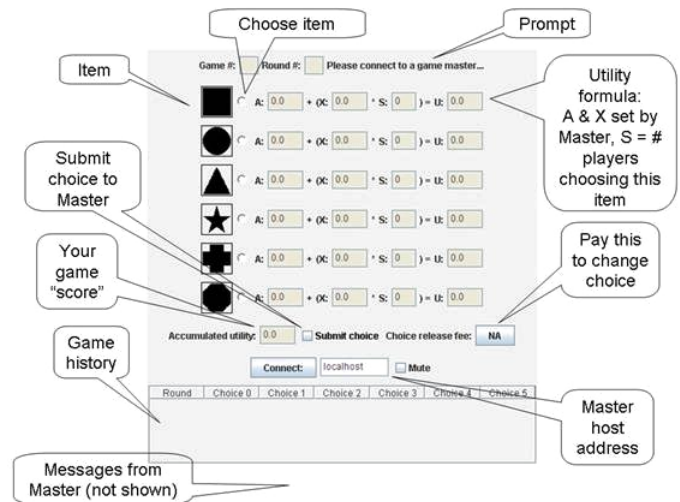


Figure 2: The Game Player Applet.

Figure 1 shows the Master application after initialization. Figure 2 shows the Player applet after initialization.

3. Software Overview

This paper provides step-by-step instructions for running five variations of a game that demonstrates network externality's affect on consumer utility, herding behavior, and standardization. In addition, this paper will demonstrate several ways that the game can be customized to address additional topics related

(1) <http://ite.pubs.informs.org/Vol8No1/WolfPortegys/UtilityGame/GameMaster.jar>

(2) <http://java.sun.com/>

(3) <http://www.rarlab.com/>

(4) <http://ite.pubs.informs.org/Vol8No1/WolfPortegys/UtilityGame/gameplayer.html>

to network externalities. As this game is based closely on Ruebeck et al.'s (2003) network externalities game, we will start by replicating their four games. Participants must decide which of the available technologies to adopt in each game. The utility the participants receive depends on the technology they choose as well as the number of other participants that also choose that same technology. Each game has slightly different rules, as explained below.

In each of these games, players' utilities are determined by the player's choices and the choices of the other participants according to the utility schedule entered into the Game Master. Before starting the game session, the facilitator enters the values. A represents the participant's utility from choosing a product or technology and X represents the utility derived from participants choosing the same (S) product or technology. Ruebeck et al. (2003) use different notations but suggest setting a/x somewhere between $n/2$ and n , where n is the number of participants each round.

Figure 3: The Game Master Application.

Figure 3 shows a setup that includes a choice of two different technologies and a utility function of both technologies of $\mu = 5 + 1 \cdot S$, where S is the number of participants that choose the same product or technology. While not used in this example, Y represents the utility derived from participants choosing a different (D) product or technology. Throughout this paper, we will examine positive externalities (i.e., X and Y are positive), however, the game has been constructed to

allow for negative externalities (i.e., X and Y can be set to negative numbers).

In these games, the symbols act as proxies of the technology or product choices for example, different instant messaging packages (e.g., MSN Messenger, Yahoo! Messenger or AOL Instant Messenger (AIM)) or different social networking sites (e.g., Facebook, MySpace or Zanga). Individual participants do not see the same symbol choices and the order of the symbols are randomized.

4. Game One - Simultaneous Choice

In the first game, participants choose one of a number symbols and their one time choice determines their utility for 10 rounds. Ruebeck et al. (2003) gave their participants a choice between two symbols but our software allows for up to six options. Adding or subtracting the number of options is accomplished by selecting or deselecting the checkbox next to a symbol on the Game Master. In addition, while we use 10 rounds for this game, others may choose to use a different number of rounds.

Prior to beginning the game, the facilitator should set the desired utilities and the number of choice options. Participants should be informed that their utility for each round is determined by the number of people who have chosen the same technology and their choice of symbol determines their utility for the entire game (e.g., 10 rounds). Participants choose by selecting the check box next to the desired symbol and then selecting the Submit Choice checkbox.

The facilitator begins the game by selecting the Start/Stop Game checkbox and then selects the Start/Stop Round checkbox. After all participants make their choices, the facilitator selects the Start/Stop Round checkbox ending the round. To move to the 10th round, the facilitator enters the number 10 into the Round # textbox and starts and then stops the round. The software then calculates each player's utility for rounds two to 10. Finally, the facilitator selects the Start/Stop Round checkbox ending the game. Each participant is shown their total utility for the game as well as round-by-round summaries.

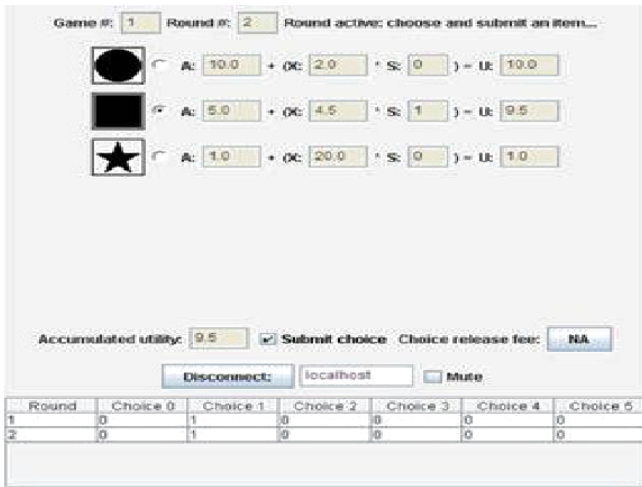


Figure 4: Player During Round 2 of Game 1.



Figure 5: Game Master During Game.

5. Game Two - Sequential Choice

In this game, participants decide in each period whether to choose a symbol or no symbol. However, once a symbol is chosen, participants cannot change their choices. Prior to beginning the game, the facilitator sets the desired utilities and the number of choice options. Participants may elect not to make a choice in any round but they will receive a utility of zero for that round. After they select a symbol, their choice of symbol will determine their utility not only for that round, but also for all remaining rounds. As in game one, each participant's utility for each round is determined by the number of people who have chosen the same technology. Again, participants choose by selecting the check box next to the desired symbol and then select the Submit Choice checkbox.

The facilitator begins the game by selecting the Start/Stop Game checkbox and then selects the Start/Stop Round checkbox. After each participant has had enough time to make their choice, the facilitator selects the Start/Stop Round checkbox ending the round. When a sufficient number of players make their choices, or a certain amount of time has passed (a timer is available as a convenience), the facilitator selects the Start/Stop Round checkbox ending the round.

The number of players choosing the various items becomes visible in the *S box* for each item. Prior to ending the round, the facilitator may want to inform the participants that the round will be ending soon and they are not required to make a choice, but will receive a utility of zero for that round if they fail to make a choice. The facilitator can relay this information verbally or use the software's *Notify players* feature. To use this feature, the facilitator simply types a message into the text box and selects the *Notify players* push button. The message is broadcast to all players and appears at the bottom of their screens.

To start the next round, the facilitator selects the Start/Stop Round checkbox. At the beginning of the next round, the player can observe the *S* values for each item as well as his accumulated utility. Each participant's accumulated total as well as a tabular history of the game is displayed.

Again, after an appropriate amount of time the facilitator ends the round by selecting the Start/Stop Round checkbox. This continues for as many rounds as it takes until all participants have selected a symbol. At this point, the facilitator ends the game by entering the number 10 into the Round # textbox and then starting and stopping the round. The software then calculates each player's utility for the remaining rounds. Finally, the facilitator selects the Start/Stop Round checkbox to end the game. Each participant is shown their total utility for the game as well as round-by-round summaries.

6. Game Three - Sequential Choice with Noisy Signals

This game only differs from game two in the information participants receive in each round about the number of people who have chosen each technology. In game two, participants are shown a summary of all participant choices after each round; in game three, participants are shown a "noisy" summary of all participant choices after each round.

The facilitator can introduce noise into the S values visible to the game participants by setting the noise slide bar. The default noise level is 0%, but can be set at any level from 0% up to 100%. The noise level represents the independent likelihood that a choice is displayed in S . For example, if the facilitator sets this value to 50% and the actual S value of a technology is 10, the resulting S values that each participant sees can be compared to 10 true coin tosses with the number of heads produced by the 10 tosses being the visible S value. If the noise level is set to 100%, all players will see S equal to 0% and thus have no idea of what items have been chosen (other than their own choice). The level of noise is set by the Game Master Application and this setting determines the likelihood if each choice is displayed. However, whether or not the choice is displayed is determined by each participant's Player Applet. As a result, it is likely that different participants see different results.

Again, each player's utility for the round is based on the known number of people choosing the same technology, i.e., the number that is revealed. This continues for as many rounds as it takes until all participants have selected a symbol. At this point, the facilitator ends the game by entering the number 10 into the Round # textbox and then starting and stopping the round. The software then calculates each player's utility for the remaining rounds. Finally, the facilitator selects the Start/Stop Round checkbox ending the game. At this point, each participant is shown their total utility for the game as well as actual round-by-round summaries.

7. Game Four - Sequential Choice with Switching Costs

This game differs from game two in the following way. After the third round, one of the symbols will be ran-

domly selected to provide a higher utility than the other. Ruebeck et al. (2003) recommend flipping a coin to choose the technology to change. Ruebeck and associates also propose that for smaller classes that it might be helpful to select the smaller of the networks. If a participant has chosen a symbol after the change in the selected technology's utility, they can change to another symbol but must pay to make the change. The cost for switching to another symbol is set by entering the amount in the *Choice release fee* textbox. Ruebeck et al. (2003) recommend increasing the utility of the selected technology by $a/4$ and setting the switching costs to a .

8. Game Five - Sequential Choice with a Universal Technology

Game five differs from game two in that one of the technology choices will have a utility function in which participants' utility for choosing that technology will be affected by two factors: the number of people who have chosen the same technology *and* the number of people that have chosen a different technology. Y represents the utility derived from participants choosing a different (D) technology. The default Y parameter is NA (not available), which means that the Y and D values are not visible to the game participants. Setting Y to a numeric value results in the screen views shown in Figures 5 and 6.

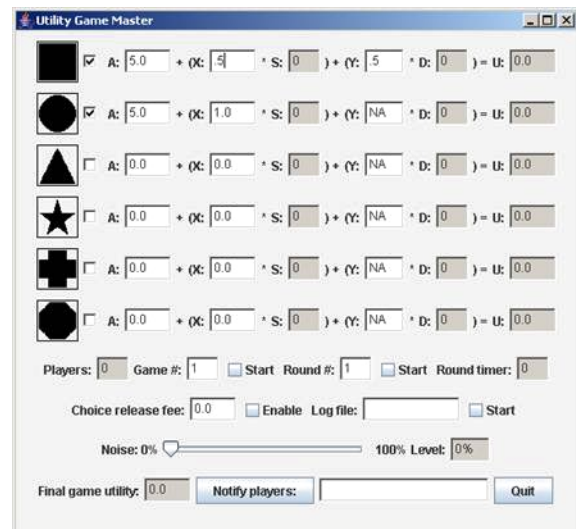


Figure 6: Game Master Application Game 5.

Figure 6 shows a game setup that includes a choice between two different technologies. The first technol-

ogy has a utility function of $\mu = 5 + 0.5*S + 0.5*D$, where S is the number of participants that choose the same technology and D is the number of participants choosing a different technology

formation: A Classroom Game," Available at SSRN,

<http://ssrn.com/abstract=740565>

9. Discussion

We have successfully run these games in several classes. Due to scheduling and space limitations, we typically run the games in groups of 10-15 and then discuss the results and implications in a large lecture session on a subsequent day. All five games can be completed in a single 50 minute session.

The lecture session that follows the game centers on technology adoption and touches on ways that firms (e.g., eBay) can benefit from network externalities and how it is possible for an inferior technology (e.g., VHS) to be adopted over a superior technology (e.g., Beta-max). Subsequently, we discuss the impact that switching costs, "lock in" and imperfect information can have on technology adoption in the presence of network externalities. The lecture concludes with a discussion of game 5. In game 5, it can be shown that students prefer a "universal technology" (i.e., one that benefits from both direct and indirect externalities) over a "proprietary technology" (i.e., one with only direct externalities).

In closing, like Wolf and Myerscough (2005), we have found that providing a small payment or reward (e.g., key chains, mugs or pens) to the participants with the highest scores encourages students to take classroom game seriously. In addition, we have also found that the desire to perform better than their classmates or "bragging rights" is also a powerful motivator.

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