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An In-Class Experiment to Teach Marginal Revenue Product Using the Baseball Labor Market and *Moneyball*[1]

We describe a class project exploring principles of marginal revenue product and labor markets through the professional baseball labor market. No prior knowledge of baseball is required to implement this project. The objective is to provide the student a better understanding of economic principles by collecting and analyzing data about professional baseball free agents. This is intended to highlight economic principles while increasing student engagement. The project culminates in an in-class draft and season simulation activity that allows the students to apply the information they have collected in order to make decisions based on their work.

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1 The authors thank Darren Grant (Sam Houston State University, Texas) for providing the basis for our initial project concept as a way to introduce a research component into his undergraduate courses. We are also grateful to our many other colleagues who provided feedback throughout the manuscript process, and our students who provided feedback that inspired us to refine the project instructions over the years.

1. Introduction

The baseball labor market captured the imagination of the public following the release of the film *Moneyball* in 2011, based on the Michael Lewis book of the same name (Lewis, 2003). Under strong assumptions, the marginal product of labor in the baseball labor market can be calculated as a function of observable statistics recorded during the course of each baseball game. It is rare for production statistics to be publicly observable in almost any market, making the baseball labor market an excellent way to introduce students to concepts that can be applied to labor markets at large.

In order to improve students' understanding of the principles of labor markets, we developed the project presented below. Our objectives in creating this project were to: (1) teach marginal revenue product (MRP) through an exciting exercise; (2) use real data to teach practical analysis using spreadsheets and trend lines to demonstrate marginal effects; and (3) show the workings of a simplified labor market with a simulation.

Using a simplified model of baseball's offensive production statistics (and based on the principles of sabermetrics and subsequent work by economists and statisticians), we seek to teach students about the workings of labor markets through a thoughtful analysis of a simplified baseball labor market.

Some students do not describe themselves as sports fans, and some sports fans are not fans of baseball. This, however, does not diminish the value of the project in an economics course. These uninterested students are frequently the students who excel at the project because they naturally understand the *Moneyball* mindset and do not bring pre-existing opinions about baseball talent to the analysis. The process of introducing this project to a class also provides an excellent opportunity for instructors to discuss the difficulty of measuring productivity in many other labor markets where productivity measures are extremely difficult to obtain.[1]

To date, this project has been successfully implemented in various mathematics, economics, and sports management courses taught by the authors. These courses include high school mathematics, principles of microeconomics, labor economics, sports economics, and sports finance. The instructions provided in the appendix were used in a principles-level course. For upper-division courses (where students are expected to have more detailed understanding of the concepts related to the project), some of the cues are removed. For example, in upper-division courses, marginal revenue product is not defined and students are asked to identify that concept on their own. Once many of the cues are removed from the instructions, some students struggle to understand how everything pieces together. This would not be ideal for a principles-level course, but can be used to encourage the higher-order critical thinking skills ideal for an upper-division course.

We believe that this project distills critical concepts in labor economics and allows students to explore decision-making through data analysis. For principles-level courses, labor concepts are often covered in a chapter on input markets, which is typically covered near the end of a semester, making this project ideal as an end-of-year assignment and activity. The project is designed to be used as either an individual project or as a team-based project, and can even be implemented as an in-class activity. The culmination of the project is an in-class simulation

1 Students are most likely to understand that the project is more about labor valuation than about sports if the instructor is very careful to emphasize this point in class. A discussion of labor productivity in general, and the difficulty in measuring worker productivity in most jobs and industries will help students to see why it is so valuable to be able to analyze this information in the sports context. Asking students to determine, for example, the value of an employee who works on a marketing team at a large soda company may help to drive home the importance and rarity of quality data on productivity.

activity that encourages students to make decisions based on the economic theories they have learned, and to apply the data analysis that they have performed in order to improve labor market outcomes for a simulated baseball franchise.

2. Literature Review

In their seminal work, Becker and Watts (1995) explore a variety of teaching approaches that go beyond the traditional lecture. Furthermore, the use of computer simulations can address many instructional goals, thereby making difficult economic concepts (such as marginal revenue product) more accessible to students, particularly those students whose primary field of study is not economics.[2]

The project that we present below emphasizes the economic principles being taught, and uses a sports labor market as the practical (and typically familiar) application in order to teach these principles. Other sports related simulations tend to focus on the overall strategic management aspect of teams (Rascher, 2005) or leagues (Einolf, 2005), and do not strictly focus on the goals of general economics courses. Our project could be viewed as an extension of the classroom simulation exercise presented by Baird (2005) where, rather than bidding blindly on players and uncovering various results, our project encourages students to develop marginal revenue product estimates for players on the market before bidding on the players as free agents in a draft. Our project utilizes the work of Hakes and Sauer (2006) in order to establish that offensive statistics can be used to estimate the contribution of players to a team's win percentage, which is assumed in the project we will present to be the revenue-generating output of a baseball franchise.[3] Much work has been done previously in determining the marginal revenue product of baseball players (see Scully, 1974; Sommers & Quinton, 1982; and Krautmann, 1999). Not only is marginal revenue product estimation valuable for sports franchises, it is also a valuable method of determining the appropriate salary for any individual whose productivity can be accurately quantified. In order to maintain the applicability of our project to other industries, we choose to abstract away from models in which super-star players have unique effects on the revenue of teams and focus exclusively on productivity statistics that are standard across all players and teams.[4]

Moneyball has been used in courses since the release of the book in 2003 (McHugh, 2009), and the film is regarded as one of the top movies for teaching economics (Mateer, O'Rourke, & Holder, 2016). Furthermore, many instructors and institutions are seeking ways to engage students in the classroom (Rocca, 2010). Many courses are already making changes: Watts and Schaur (2011) find that traditional lectures are currently utilized 65 percent of the time, compared to the 73 percent reported in 1995 and that an average 8 to 11 percent of economics faculty use some sort of simulations or experiments in the classroom currently, where more than half of all economics instructors reported spending no class time employing experiments in 1995.

2 For a more thorough review of the literature on the use of simulations in the classroom, see Porter et al. (2004).

3 There exists considerable debate over whether competitive balance or wins exert greater influence on revenue. Estimating wins is a simpler concept, and is therefore our chosen output for this project. Our primary goal is to keep the project simple enough to teach the principles of marginal revenue product in a way that can generalize to other labor markets, and this is best done by simplifying the exercise whenever possible.

4 For an example of a model that specifically accounts for super-star players, see Berri, Schmidt, and Brook (2004).

3. Project Overview

The project does not require intimate knowledge of baseball or of statistics or econometrics, but some familiarity with aspects of the sport can help students move through the project without feeling lost in the details of the game. Many students who are not knowledgeable about sports express concern that they will be penalized for not being as familiar with professional baseball as their peers. It should be stressed to these students that grading depends only on careful economic analysis, and that a lack of understanding of baseball will not prohibit students from earning full points.

There are many steps involved in this project. During the course of the project, students will:

1. Collect data on total team attendance (summed over all home games), *average* ticket prices by team, win percentage, and offensive statistics.
2. Calculate total revenue for each team.
3. Calculate an offensive index for each team.
4. Calculate the marginal revenue of offensive output in Major League Baseball.
5. Collect player-level offensive statistics and current-season salary.
6. Calculate the marginal product of free-agent baseball players.
7. Use marginal revenue from team calculations and marginal product for individual players to estimate marginal revenue product, or the expected one-year salary of the players.
8. Compare predicted salaries with actual salaries for the upcoming season to see how well their measurements predict future pay.
9. Implement this analysis to competitively select players during an in-class simulation activity.

The project requires that students collect data from the previous season of Major League Baseball, manipulate the data through a series of spreadsheet calculations, and then analyze trendlines to make predictions regarding player value. Data regarding actual salaries are also collected for the upcoming season in order to compare the estimated value and actual salary.

Students begin by collecting data from various websites regarding Major League Baseball. After the collection of team-level data is completed, students calculate total ticket revenue (using attendance and ticket prices for each individual team) and create an index of performance (using statistics for on-base percentage and slugging average). The index of offensive performance is then used to estimate both marginal revenue for the team and marginal product for a player. The estimated index is based on empirical work by Hakes and Sauer (2006) and exposes students to economic research.

An estimate of marginal revenue is calculated using a performance index and the relationship between team performance and ticket revenue for the previous season. Using trendline equations, students should interpret the slope as the additional revenue generated by a team from a one-unit change in the performance index. In the onset of the project, the focus is on changes at the team (firm) level impacting revenue.

Students next collect data on individual free-agent baseball players. Player position is ignored for the sake of simplicity, but students should be instructed to exclude pitchers from their samples.[5] They are then equipped to estimate the extent to which an individual player (worker) impacts the organization's overall performance. The same performance index is calculated on a player level, but modifications are made to emphasize the concept of marginal product.

In order to measure the impact of a particular player on a team, all players are compared against a baseline player nicknamed the "Mendoza Player," named for Mario Mendoza. Mendoza is infamous in baseball lore as an archetype of the minimum talent level that should ever be observed in professional baseball. To identify the impact of a free agent, students measure the additional performance of players relative to a Mendoza player, since a minimally-talented player is always available at minimum wage. This is equivalent to a fast-food chain searching for a highly talented fry cook, while keeping in mind that a minimally-capable fry cook is always available at minimum wage. If no available cook justifies a higher wage, then the organization will hire a cook at the lowest possible salary (minimum wage). The Mendoza Player is simply the embodiment of this concept in the baseball labor market.

To conclude the project, students combine their analysis of marginal revenue and marginal product to estimate the additional marginal revenue product that a particular player brings to a team compared to a Mendoza Player. Because the marginal revenue calculation looks at team-level performance, the marginal product calculation for the players needs to take into account that the firm is looking to hire only one additional player and not an entire team fielded by that one player. Because there are nine active batters in the lineup for each game, the marginal product estimation is divided by nine to consider only the impact that a single player has on the overall performance of a team. Combining these two calculations, students estimate the value of player performance on ticket revenue. These values are scaled upward by the league-minimum salary to allow the calculated value of the player to represent an estimated salary. Again, this is to allow a comparison between the player's output and the output generated by a minimally-talented player who would earn the league minimum wage. Students then compare this estimation with the player's actual upcoming salary to determine if a player is under- or over- valued relative to his actual salary.

After completing the project, students participate in an in-class simulation where they are divided into teams and take turns selecting players from the free-agent list used in the project onto their own "team." They must use what they have learned in the project to find the players with the highest output and lowest salary in order to create the best team possible subject to a budget constraint (salary cap) chosen by the instructor. Once nine players have been allocated to each team of students, the team-level offensive index is calculated for each team, and a season is simulated. The purpose of the simulation is to allow students to *apply* the principles learned throughout the project to make decisions that are similar to those made by firms competing for talent and profit in the real world.

The discussion that follows the project and simulation typically revolves around why a player may not be paid exactly their estimated marginal revenue product and what other areas of revenue a firm may be trying to increase in addition to ticket revenue. The analysis portion of the course typically brings a higher level of discussion than a traditional approach to teaching marginal revenue product because students are quick to identify a variety of different factors that are unaccounted for in the estimation. This can segue into a discussion on the assumptions used in the traditional economic approach to estimating marginal revenue product, both in

5 Pitchers are valued differently than position players, and cannot be accurately priced based on their offensive statistics alone. Furthermore, for the purpose of simplification, we select players as if defensive position is irrelevant, and that offensive output is the only characteristic of baseball players that affects a team's ability to win.

baseball and in other industries.

4. The Project Instructions for Students

Below are the instructions that the authors provide to their students when implementing this project in a principles of microeconomics course. A copy of these instructions that can be readily distributed to students is available at http://moneyballsimulator.info.

A. Project Aim

This project is designed to help you understand how labor inputs are related to revenue in Major League Baseball (MLB). We will do this by analyzing the offensive skills of free-agents in baseball and the relationship of these skills to firm output (measured as team ticket sales). We will use a simplified model of player skill based on the conclusions of the article "An Economic Evaluation of the *Moneyball* Hypothesis."[6] In order to complete this project, you will collect data from several sources (provided in the list below) that measure individual and team statistics, salary information for individual players, and attendance and ticket cost information for each team in the MLB.

After completing the analysis, you will write a short paper explaining what you did, why it is informative, and then list your conclusions. The paper should be 3 to 5 pages, and specific points to address in the paper will be provided below. The following sites will be useful as you collect data:

- Player Salary Database (be sure to select the last completed season): http://www.spotrac.com/mlb/free-agents/
- Player Batting Statistics Database (be sure to select the last completed season): http://www.baseball-reference.com/
- Team Batting Statistics (be sure to select the last completed REGULAR season statistics): http://www.espn.com/mlb/stats/team/_/stat/batting/
- Team Attendance Statistics (be sure to select the last completed season): http://www.espn.com/mlb/stats/team/_/stat/batting/
- Team Win Statistics (be sure to select the last completed REGULAR season): http://www.espn.com/mlb/standings
- Average Ticket Prices by Team (be sure to select the last completed season): https://www.statista.com/statistics/193673/average-ticket-price-in-the-mlb-by-team/

B. The Basics

You will create a Google Drive folder and share access with each of your teammates and your instructor.[7] You will use Google Sheets so that you can work collaboratively with your teammates to collect data throughout the project. You will also use a Google Doc to complete your write-up. All elements of the project (including plotting, estimating trendlines, and graph-

6 Hakes, J. K., & Sauer, R. D. (2006). "An economic evaluation of the *Moneyball* hypothesis." *Journal of Economic Perspectives 20*(3), 173-185.

7 Creating Files and Folders: https://support.google.com/docs/answer/49114?hl=en&ref_topic=4722291 Sharing Files and Folders: https://support.google.com/docs/answer/2494822?hl=en&ref_topic=4722291

ical analysis) can be completed in Google Drive using Docs and Sheets.[8]

C. Teams

The class will be divided into multiple "teams." These teams should be made up of no more than four individuals. You will work together to operate as the general manager of an imaginary baseball franchise, and will make personnel decisions based on a player's statistics from the previous season.[9] You are expected to be a contributing member of your team throughout the process of completing this project.

D. Part 1 – Understanding Firm Output

After reading "An Economic Evaluation of the *Moneyball* Hypothesis" by Hakes and Sauer, you will collect team-level data for all 30 MLB teams and use it to assess the impact of offensive success in baseball on the revenue generated by the firms (teams) in MLB. The following instructions describe how to collect and organize the information in a spreadsheet.

1. Place the team names in the first column of your spreadsheet, with the first cell labeled "Team."

2. Label the second column "OBP," and collect the **team** on-base percentage (OBP) for each team in MLB, and enter the values in the cells corresponding to those teams (use the information from the **regular season**).

3. Label the third column "SLG" and enter each team's **regular season** slugging average (SLG) into the cells corresponding to each team.

4. The paper by Hakes and Sauer (2006) lists OBP and SLG as the most important factors in determining the number of runs (and, ultimately, wins) that a team earns. The authors find that OBP is twice as important in determining these outcomes as SLG. Create an index of offensive production in the fourth column, and label the column "Index." The index should be calculated using the following formula:

$$\text{Index} = 100 \times [(2 \times \text{OBP}) + \text{SLG}]$$

Note: We multiply by 100 in order to have numbers that are easier to read.

5. Label column 5 "WinPercentage." Collect the **regular season** win percentage of each team, multiply by 100 (so that a team with a 0.500 win percentage has a value of 50.0), and enter the data in the cell corresponding to the correct team.

6. Label column 6 "Attendance" and column 7 "TicketPrice." Collect the **total** attendance for each team, as well as the **average** ticket price for each team during the most recent completed season, and enter the data in the corresponding cells of the spreadsheet.

7. Label column 8 "TotalRevenue," and calculate the cell according to the following equation:

$$\boxed{\text{TotalRevenue} = \text{Attendance} \times \text{TicketPrice}}$$

8 Help with any problems using Google Docs (or sheets) throughout the project can be found by searching the help documentation available at https://support.google.com/docs/?hl=en#topic=1382883

9 For information on why using past performance to model future pay and performance in sports is frequently a dangerous idea, see *Stumbling on Wins* (by Berri and Schmidt) and *Scorecasting* (by Moskowitz and Wertheim).

8. Using the information you have collected and calculated, create three scatter plots. In each scatter plot, include the linear trendline and select the option to display the equation of the trendline. The three plots you should present are:

    1. Team Revenue (*y*-axis) to Index (*x*-axis)

    2. Team Revenue (*y*-axis) to Win Percentage (*x*-axis)

    3. Win Percentage (*y*-axis) to Index (*x*-axis)

Each trendline will be formatted as a traditional linear equation of the form $\boxed{y = mx + b}$. For our purposes, we care about the coefficient of the trendline (the *m* in the equation above). This coefficient shows us the slope of the trendline and is equal to the amount by which y will increase when x increases by one unit.

9. Be sure to answer the following questions in your write-up:

    a. What is the effect of a one-unit increase in the Index on Total Revenue?

    b. What is the effect of a one-unit increase in the Index on Win Percentage?

    c. Is the value of the coefficient (*m*) from the third plot (WinPercent vs Index) times the coefficient from the second plot (TotalRevenue vs WinPercent) close in value to the coefficient from the first plot? If true, this equality could be written:

$$\boxed{\text{Coefficient}_2 \times \text{Coefficient}_3 = \text{Coefficient}_1}$$

    What might this suggest generates the demand for sporting events?

E. Part 2 – Estimating the Value of Player Talent

In this portion of the project, you will make use of the information about baseball franchises from Part 1 to predict the value of the contributions of free-agent baseball players to their new teams. This information will allow you to determine whether or not you believe that a given player is over- or under- valued according to their offensive statistics only.

1. Using the list of free agents for the current (or most recent) offseason, select 30 players *randomly*.[10] Note that all players should be position players, not pitchers. Please be sure to explain the process that you use to select the 30 players at random. Place these 30 players' names in the first column of a new spreadsheet (You may also use a column for first name and another for last name if you choose).

2. Using the Player Batting Statistics Database listed at the top of the assignment, obtain the most recent OBP and SLG statistics for each of the 30 players on your list. Label the second column "OBP" and the third column "SLG," and enter the values in the appropriate cells. *Note: For some players, you may have to use minor league statistics to obtain recent OBP and SLG values. We will pretend for the purposes of this project that these numbers accurately reflect how the player will perform in the major leagues, even though this is a VERY strong assumption.*

3. Collect each player's salary from the Player Salary Database. Use the salary for each player in the *upcoming* season, not his past salary. If a player has no salary, assign them a salary of $535,000 (approximate league minimum salary). Enter these values in the fourth

10 Google Sheets has a built in "RANDOM" function that is useful in selecting players randomly.

column, and label the column "Salary."

4. In the fifth column, calculate the player's offensive index using the same equation as you used for the team offensive index. (See Part 1 – Step 4).

5. Label the sixth column "Difference." Subtract the offensive index value for a Mendoza Player (one who has an "OBP" of 0.250 and an "SLG" of 0.300) from the index value calculated for each player in the previous step.

$$\boxed{\text{Difference} = \text{Player's}\text{Index} - \text{Mendoza}\text{Index}}$$

6. Label the seventh column "Marginal Product." Divide the "Difference" value of each player by nine, because a player can only play, at most, one-ninth of the team's at-bats. A single player's index value will represent about 11 percent of the team index value. Note that each individual player's MRP is in fact his MRP minus the MRP of a Mendoza player. If we generate an entire team's MP, we should start with a baseline MP of (80 × 9), and then add the "Difference" that we have calculated for each player to that number. The original (80 × 9) index represents a team composed only of Mendoza players (the worst team that should ever be fielded in our imaginary world, since another Mendoza player can, in our theoretical world, always be found). Adding the MP values of all players to this base of 80 would then generate an accurate team-level performance index.

$$\boxed{\text{Marginal}\text{Product} = \text{Difference}/9}$$

7. In the eighth column, multiply the "Marginal Product" value for each player by the revenue generated at the team level for each additional unit of offensive output. Revenue generated is equal to $535,000 plus the **slope** of the trendline from the Index vs. Revenue plot in Part 1 of the project multiplied by the actual output. We add the league minimum wage to a player's MRP because this is the amount that must be paid to players whose marginal product (our calculated "Difference" divided by 9) is equal to zero. All valuations should take this into account, because we are trying to determine how much value a player generates *beyond* the value generated by a Mendoza Player. Label this column "MRP" (Marginal Revenue Product). This value is an estimate of the revenue generated by a team that signs a particular player, and in a competitive market should be the amount paid to the player for signing with a team.

$$\boxed{\text{Marginal}\text{Revenue}\text{Product} = 535,000 + \text{Marginal}\text{Product} \times \text{Marginal}\text{Revenue}}$$

8. In the ninth column, use an "if" statement to assign a value of "undervalued" to any player whose MRP is greater than his salary, and a value of "overvalued" to any player whose MRP is less than his salary. Remember, these values are stored in columns 4 and 7.

9. Make a scatterplot of the true salary (*x*-axis) and the predicted salary (*y*-axis) of each player in your sample.

10. Using the plotting tools in Google Sheets, determine the value using projected salary and actual salary. Using the CORRELL function, calculate the correlation coefficient for these two variables.[11]

11 The R^2 and correlation coefficient questions asked in the assignment can easily be omitted where statistical understanding of those topics is lacking (or the correlation coefficient portion could be retained without the R^2 where that would better suit students). A visual analysis of the under- or over- valuation of player talent would be sufficient to reach the same conclusions that would be determined statistically.

11. Be sure to answer the following questions in your write-up:

    a. How close are these estimates to the true salaries of each player? What do you think might cause the differences?

    b. What do the and correlation coefficient tell us about how players are valued in Major League Baseball compared to our projected values for free agents?

F. What to Turn In

Write out, in three to five double-spaced, typewritten pages:

1. What you did, including how you calculated the cells in your spreadsheets.

2. Why this process might be valuable to a professional baseball team, and how the information that you calculated should be used in order to make a baseball team more profitable.

3. Conclusions. Explain what this project tells you about the market for baseball players, and how this information could be applied to other markets.

5. Implementing the Project in Class

The following three subsections outline different approaches to implementing the project during the semester. If time allows, the project can be completed in class as group work and then the simulation can be reserved for an additional class where students actively apply their knowledge from the project. The project may also be assigned as an independent project to be done outside of class with just one day in class reserved for applying the material with the simulator.

In all of the scenarios listed below, the authors have found that the project is most successful when students are already familiar with *Moneyball*, either through exposure to the film or the book itself. Additionally, students should already be familiar with how prices for goods and services are established in perfectly competitive markets, as well as the concept of marginal revenue product as a method of determining the value of inputs. Given this background knowledge, a student should be adequately prepared to complete the project.

A. Illustrative Exercise - Approximately 2.5 Hours

When presenting this project and simulation as an illustration of basic principles of economics to students unfamiliar with the topic (in a mathematics course, for example), it is useful to first acquaint the audience with the problem faced by producers of finding the most labor talent for the lowest price. Presenting the story of Billy Beane and the Oakland Athletics and their ability to find inexpensive talent then showcases the way in which economic principles, and a careful use of data analysis, can enable firms to make better decisions. This discussion should include the basic principles of competitive markets and marginal revenue product as a method of valuing talent.

The students will then compete, using the information that you provide to construct an ordered list of players who they think will perform best given the budget constraints of the draft (see Section "Using the Simulator" for more information). The audience should be provided with the full roster of free agents, as well as their offensive statistics, index value, actual

salary, and predicted salary.

If you are teaching a larger class and need to ensure enough free agents are available for selection, you may want to include free agents who recently played in the minor leagues and have no recent experience on major league rosters. The instructions presented in this paper include a note about minor league players because the authors normally include minor league free agents to ensure that there are enough players for students to select from when drafting their teams. If an instructor is teaching smaller classes or forms large enough groups to limit the number of teams, minor league players could be removed from the analysis entirely.

About a half hour should be used for introductory material, and one hour devoted to preparation for the draft and simulation, leaving an hour to complete the draft and simulation.

B. In-Class Lab - Approximately 5 Hours In-Class

The in-class lab, together with the in-class simulation of a baseball season, should be expected to take about five hours of lab time, as well as sufficient time for completing the write-up of results. Three of the lab hours will consist of students collecting and analyzing data, one hour will consist of students creating an ordered list of all available free agents in order to select players for the simulated season, and the final hour will be allotted to selecting players for each team and simulating a season of baseball. During the data collection time, students will follow the directions found in Part 1 of the project instructions to collect data on all 30 Major League Baseball teams. This information will be used to determine the value to a typical franchise of increasing offensive output through purchases of additional player talent.

After collecting team-level data, students will collect information regarding 30 random baseball players who were free agents during the past baseball offseason. These players are used, because they are able to freely negotiate the price for their services with any (or all) teams in Major League Baseball. This market is, for the purposes of the project, reasonable to treat as a perfectly competitive market.

As students follow the instructions in Part 2 of the instructions, they will determine the market value of player talent (measured as one unit of offensive index). Using this market value, students will then determine the value of the specific free agents that they have chosen. This will allow students to determine whether or not a player was signed to a contract of the appropriate value during the offseason, or if the player was over- or underpaid.

Once all information has been collected for the completion of the project, the students should then be provided with the complete list of free agents for the offseason, together with the salaries and OBP/SLG statistics for each player. This information can then be used by the students as they spend the next two hours preparing and implementing a draft of players and a simulation of a season using the drafted teams.

C. Semester Project - Approximately 3 Hours In-Class

In this case, students should be primarily self-guided, aside from an introduction to the project as it is assigned in class. Students should work in groups to collect data, analyze the value generated for teams, predict the value of players, and complete the write-up outside of class. The instructor should only reserve enough time in class to allow groups to prepare using the complete list of free agents as described above, and to complete the draft and simulation exercise in class. Outlining the exercise and student preparation for the draft should take the bulk of this time, and the drafting simulation should take approximately 30 to 45 minutes with careful time management.

The draft and simulation activity should typically occur after the project has been turned in and students have had in-class time to prepare for the draft.

6. Common Struggles

In each semester, some students will have difficulty understanding one or more aspects of the project instructions. While we have done our best to update the instructions in order to prevent confusion, each cohort of students has new, unique perspectives that cannot be easily anticipated

We recommend holding office hours, or making use of lab time, to be available for students to ask questions that may not be applicable to the entire class. This has been the most successful remedy found to date for resolving the unique questions that will inevitably arise during the implementation of this project.

While we have had success implementing this project in classes with students who are both highly enthusiastic about sports topics as well as students with little if any interest in sports. We find that, as long as the instructor takes care to emphasize the generalizability of the techniques involved in the project, all of our students are able to maintain enthusiasm for the project. Students uninterested in sports often take particular pride in finding ways to out-perform the students they perceive as having an advantage in completing the project. We frequently encourage this behavior by rewarding the best-drafting team with extra credit.

7. Using the Simulator

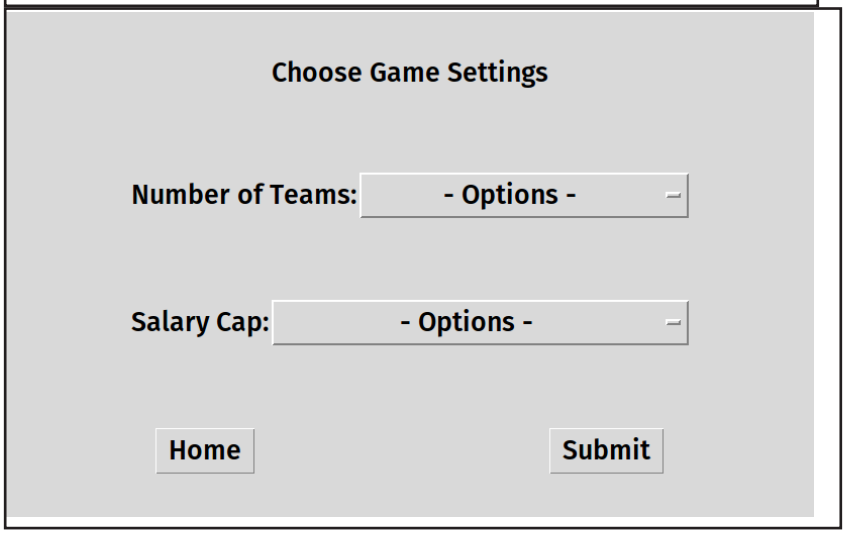
The simulator designed for use with this project can be downloaded at no cost at http://moneyballsimulator.info. It is available for Windows, macOS, and Linux as an executable file. The only other requirement of the program is a CSV-formatted table of free agents from the most recent offseason, which is provided on the same website as the simulator.

Figure 1 - Simulator Main Menu

Once the program and data file have been downloaded, opening the simulator program will present the user with three options (see Figure 1). The first option will simulate a draft that will be followed by a regular season simulation in which each team plays 10 games against each other team, and concluding with a seeded tournament based on the win percentage of teams in the regular season. The second option simulates the draft and regular season, but omits the playoffs. The third option exits the simulator.

After selecting a simulation with or without playoffs, the instructor is presented with two dropdown lists for choosing the number of teams and salary cap, respectively. This screen is presented in Figure 2. A season can be simulated with as few as two or as many as ten teams, and with salary caps ranging from $20 Million to $40 Million in increments of $5 Million. After making selections, the instructor advances by using the "Submit" button at the bottom of the screen. The "Home" button will return the instructor to the main menu.

Figure 2 - Team Selection and Salary Cap Menu

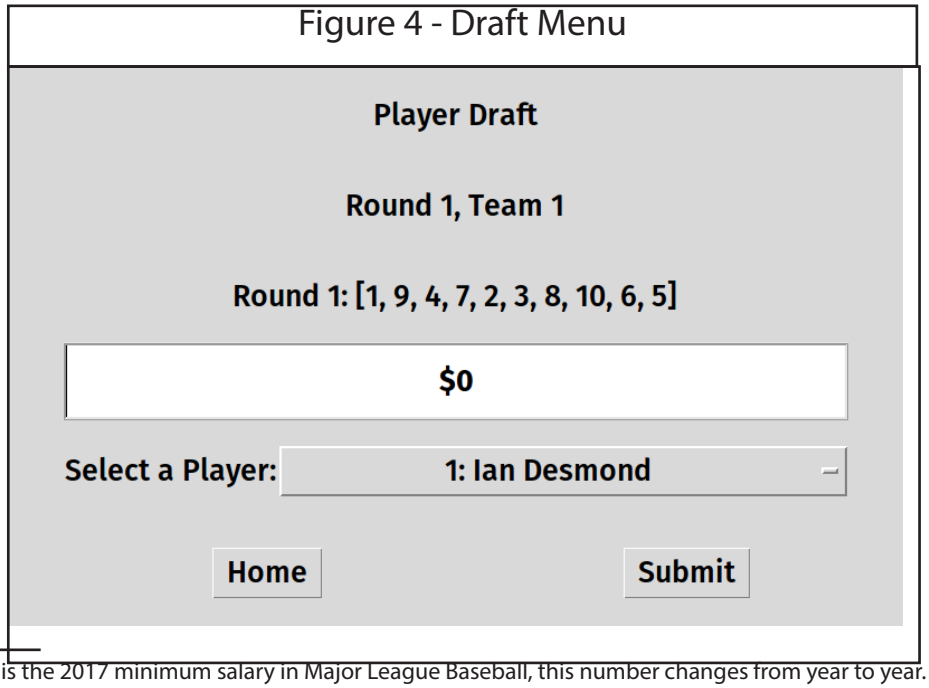


The next screen, shown in Figure 3, asks the instructor to choose a roster file of free agents. Clicking the button to select the file will open a browser, allowing the instructor to select the table of free agents downloaded with the simulator. This file can be obtained from the same site as the program itself. Once selected, the program will present the path to the selected file. Clicking "Submit" will advance the simulator to the start of the draft.

Figure 3 - Roster Selection Menu

After selecting the appropriate parameters, the draft process begins. There are nine rounds to the draft, since each team of students must select nine players to field a complete batting lineup. Each team will choose one time during a given round, and the order of the teams is determined randomly. The team that picks first in one round will pick last in the following round, and the positions of all other teams are also inverted from one round to the next. Teams are not permitted to select a player who was already chosen by another team. Teams are permitted to make one selection per round until they exceed the salary cap chosen by the instructor. If the salary cap is exceeded by a team, then all subsequent selections are forfeited, and the team is filled out with Mendoza Players at the league minimum wage of $535,000.[12] The draft continues until all teams have nine players. The draft menu is shown in Figure 4.

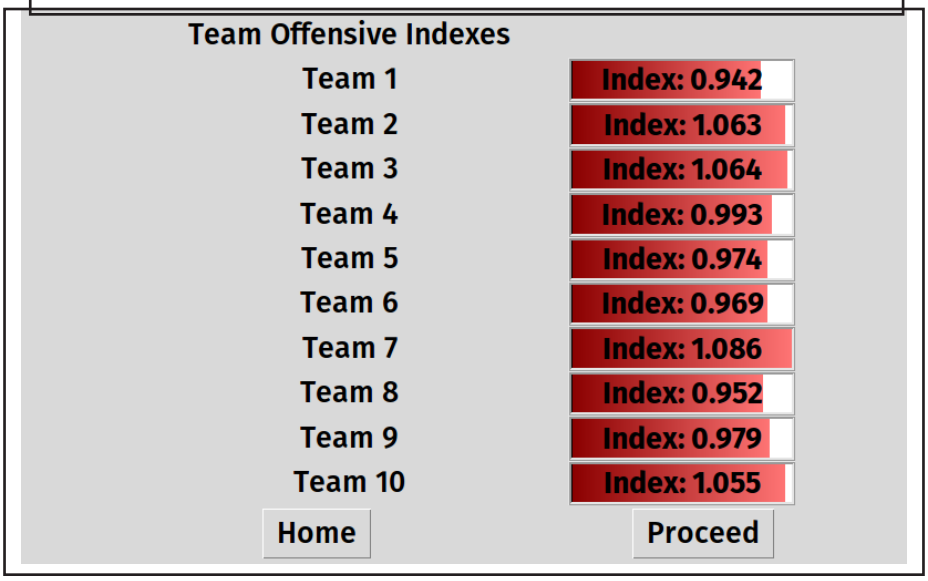
Figure 4 - Draft Menu



12 While this is the 2017 minimum salary in Major League Baseball, this number changes from year to year.

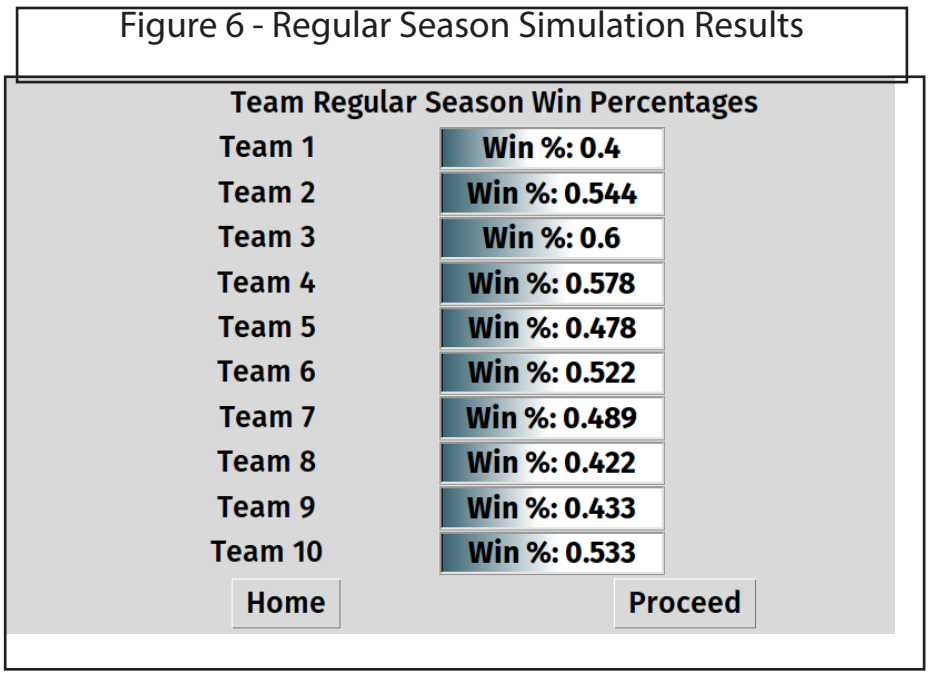
Once the draft is complete, the simulator presents the total offensive index for each team, which will be used in simulating the outcomes of the regular season and, optionally, the playoffs. This screen is presented in Figure 5. Selecting "Proceed" will advance the simulator to the results of the regular season.

Figure 5 - Team Offensive Indexes



As seen in Figure 6, the next screen displays the winning percentage (from 0 to 1) for each team following the simulated season. If the instructor chose to simulate a season with playoffs, these results will dictate the seeding of the playoff tournament. In this case, clicking "Proceed" will advance the simulator to the first round of the playoff tournament. If not, then clicking "Proceed" will return the instructor to the home screen.

Figure 6 - Regular Season Simulation Results



If the instructor selected a season with a playoff tournament, then the results of each round of the playoffs is printed to the screen as the instructor advances, with the instructor selecting the "Continue" button to advance to the next round of the playoffs, as shown in Figure 7. After the final round in the playoffs (the "Championship Series"), the instructor can select the "Home" button to return to the main menu, as illustrated in 8.

Figure 7 - Playoff Results

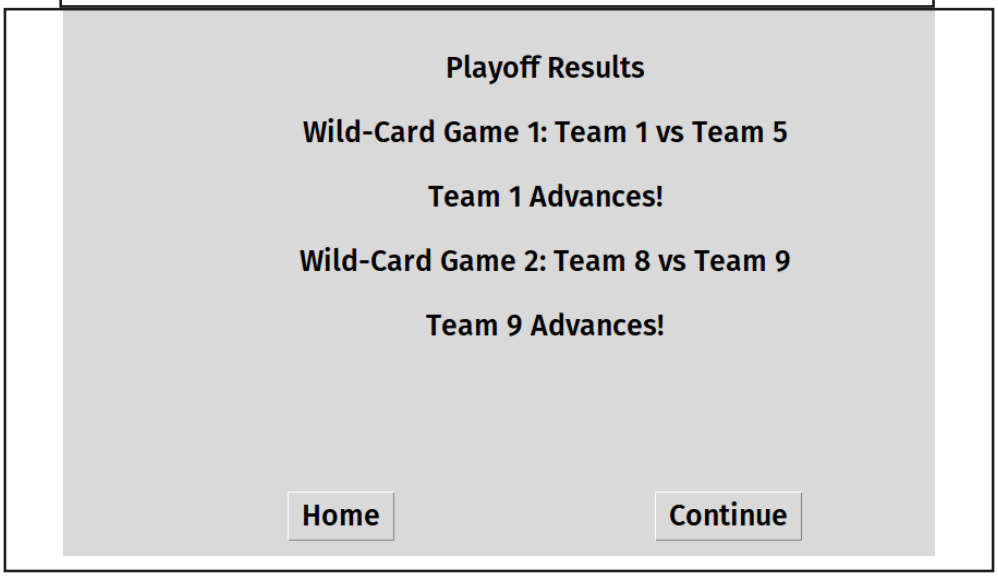
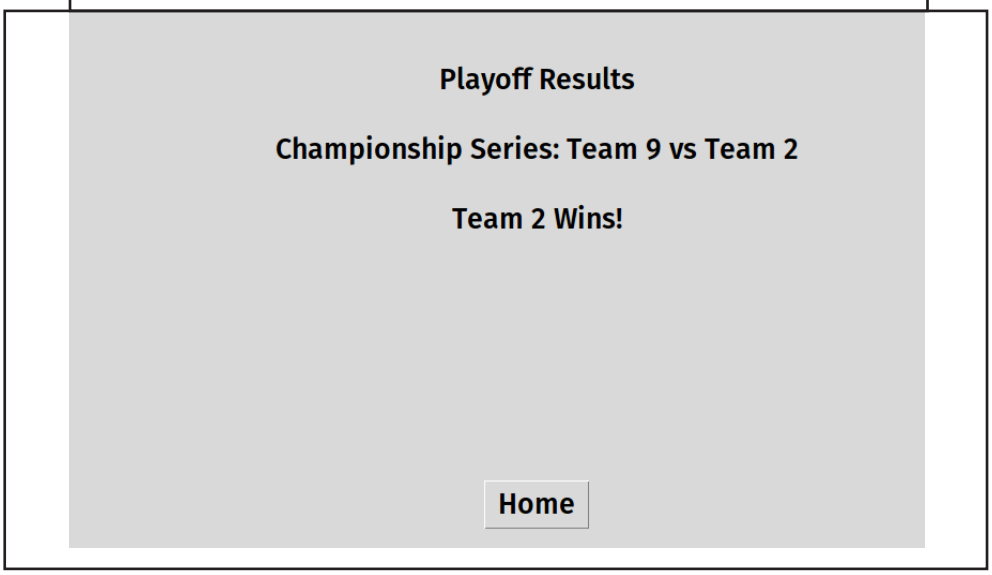


Figure 8 - Playoff Results



8. Adjustments for Upper-Division Courses

While the instructions included here are focused on principles-level analysis, there are extensions to the project that can prepare the project for an upper-level course in labor or sports economics. These changes might include a reduction in the level of detail provided in the instructions (to emphasize higher-level critical thinking skills), a requirement for more discussion regarding specific assumptions or outcomes, or more Socratic discussion in class during the simulation. Each level of adjustment is contingent on course material, instructor comfort, and time allotment during the semester.

To expand on the project in upper-division courses, instructors may be interested in tying the project into lessons regarding other labor or sports topics. A few examples for instructors are detailed below.

1. An instructor might choose to discuss monopsony markets for professional players and market power in labor. Major sports in the United States typically enjoy monopoly status, with no real alternative sources of employment for an individual wishing to work as a professional athlete. This provides an excellent contrast to both theoretical perfectly competitive markets for labor, as well as labor markets in global sports like soccer.[13]

2. An instructor could also take the chance to discuss collective bargaining decisions for unions and the choice to strike as a decision based on the probability of success as well as the expected payout of a successful strike.

3. As mentioned previously, this project makes it easy to highlight the difficulty of measuring the productivity of workers in many markets, and therefore it may lead to discussion or assignments to detail how productivity of labor could be measured in various markets or professions.

4. One of the early assumptions of the project is that marginal revenue is consistent across all teams. While the competitive markets assumption may be appropriate for principles courses, it is overly simplistic for most upper-level courses.

5. Instructors can discuss multi-product sellers and how marginal revenues for teams in New York or Los Angeles may be larger than teams in Detroit or Arizona because of merchandise and television contracts. This can be seen in the data collection section as a player playing for the New York Yankees may be paid significantly more than a player with similar statistics who plays for the Detroit Tigers.

Covering topics like those described above can lead to a richer discussion throughout the project, while the project can help students to understand how these topics can be used in context.

9. Conclusion

This project is intended to be an active illustration of utilizing economics to determine the value of labor in a competitive market. While the market for baseball talent is in many ways unique, the principles that underlie the estimation of player productivity are the same as those used in determining the value of computer programmers, construction workers, car manufacturers, and almost any other occupation group. By utilizing a project in which students must

13 An excellent interview that touches on these differences was given by Stefan Szymanski: https://www.hudsonriverblue.com/2015/2/23/8091403/exclusive-soccernomics-stefan-szymanski-talks-dollars-data-mls

determine player (worker) value for themselves, they apply economic principles that are valuable in any profession in which an understanding of worker value is beneficial.

The most valuable lesson resulting from the project for students in any business field is the ability to evaluate the revenue generated by individuals or business outcomes, and to compare that revenue to the cost of hiring the individual or completing the business transaction. As firms seek to gain advantage over competitors, it is valuable to generate new insights and efficiency through careful analysis of available data.

The materials for this project can be accessed at http://moneyballsimulator.info, and are freely available to all individuals interested in employing this project to teach economics.

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