The Relationship of a Basketball Efficiency Rating System to Game Outcome

Carol Elizabeth Jones

The College at Brockport

Follow this and additional works at: https://digitalcommons.brockport.edu/pes_theses

Part of the Other Education Commons, and the Sports Studies Commons

Repository Citation


This Thesis is brought to you for free and open access by the Kinesiology, Sport Studies and Physical Education at Digital Commons @Brockport. It has been accepted for inclusion in Kinesiology, Sport Studies, and Physical Education Master’s Theses by an authorized administrator of Digital Commons @Brockport. For more information, please contact digitalcommons@brockport.edu.
The Relationship of a Basketball Efficiency Rating System to Game Outcome

A Thesis
Presented to the
Department of Physical Education and Sport
State University of New York
College at Brockport
Brockport, New York

In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Education
(Physical Education)

by
Carol Elizabeth Jones
August, 1993
State University of New York
College at Brockport
Brockport, New York

Department of Physical Education and Sport

Title of Thesis: The Relationship of a Basketball Efficiency Rating System to Game Outcome

Author: Carol Elizabeth Jones

Read and Approved by: Daniel E. Smith

Marilyn Cady

August 30, 1993

Accepted by the Department of Physical Education and Sport, State University of New York, College at Brockport, in partial fulfillment of the requirements for the degree Master of Science in Education (Physical Education).

Date: 9/3/93

Chairperson, Department of Physical Education and Sport
Acknowledgments

Thank you to all those who have given me support throughout my educational pursuit. A very special thank you to Dr. Dan Smith for giving me the idea and permission to evaluate his efficiency rating system. His guidance, support, suggestions and promptness were greatly appreciated. Thanks is extended to Dr. Marilyn Colby for taking the time to read my work and provide suggestions in the editing process.

Also, thank you to all the Physical Education faculty at the State University of New York, College at Brockport who inspired me to pursue a thesis, especially Dr. Tom McIntyre and Dr. Connie Koenig-McIntyre. Thanks to all my fellow classmates and everyone else who have given me direction, encouragement and assistance on the road to completing my Master's degree.

Appreciation is extended to the sports information directors at Syracuse University, the University of Rochester and the State University of New York, College at Brockport for providing me with the necessary data needed to complete the investigation.

Lastly, I would like to thank all my family for the wonderful support they provided. To my husband Dave, who was always there to provide support and proofread my thesis and to Ashley and Emily who were very patient and quite helpful at times - thanks a million!

The problem was to determine whether Smith's (1983) basketball efficiency rating system was a valid method of evaluating individual player's performance and predicting game outcome. Subjects were the 1990-91 Syracuse University men's collegiate basketball team and their opponents, 1991-92 University of Rochester men's collegiate basketball team and their opponents and four seasons (1988-1992) of the State University of New York, College at Brockport men's and women's collegiate basketball teams. Data, collected from the sports information directors, included each team's basketball box score statistics for the season. Efficiency ratings were calculated and three correlations were analyzed using the Pearson Product Moment Correlation Coefficient to determine the relationship between the variables: points scored and efficiency ratings, minutes played and efficiency ratings, and team point differences and average team efficiency rating differences. The Critical Values of Correlation Coefficient Table revealed a significant relationship between the three correlations. Therefore, end of game efficiency rating comparisons are a good indication of game outcome and Smith's (1983) efficiency rating system appears to be a valid, reliable and objective evaluation tool.
Table of Contents

Page

Acknowledgement .................................................................................................... iii
Abstract ................................................................................................................... iv
List of Tables ............................................................................................................ viii
List of Figures .......................................................................................................... ix

CHAPTER 1 Introduction ......................................................................................... 1
  Statement of the Problem ............................................................................ 6
  Hypothesis ................................................................................................... 6
  Significance of the Investigation ................................................................... 6
  Delimitations ................................................................................................ 8
  Limitations ................................................................................................... 8
  Definition of Terms ....................................................................................... 10

CHAPTER 2 Review of Literature ............................................................................ 14
  Nature and Use of Performance Evaluations ................................................ 14
  Importance of Basketball Statistics .............................................................. 18
  Use of Computers in Sports Statistics .......................................................... 20

CHAPTER 3 Methodology ....................................................................................... 22
  Subjects ...................................................................................................... 22
  Data Collection ............................................................................................ 23
CHAPTER 4 Analysis of Data

Correlation 1

Individual Points Scored per Game to Individual Efficiency Ratings per Game

Calculating correlation coefficients (r) for the 12 teams

Calculating correlation coefficients (r) for the women's population, the men's population and the total data sample

Correlation 2

Individual minutes played per game to individual efficiency ratings per game

Calculating correlation coefficients for the 12 teams

Calculating correlation coefficients for the women's population, the men's population and the total sample of data

Correlation 3

Game outcome difference to average team efficiency rating difference
CHAPTER 5 Summary ............................................................................................ 48
  Conclusions ........................................................................................................ 49
  Recommendations ............................................................................................ 50

Appendix A ........................................................................................................... 51
Appendix B ........................................................................................................... 53
Appendix C ........................................................................................................... 56
Appendix D ........................................................................................................... 57
Appendix E ........................................................................................................... 58
Appendix F ........................................................................................................... 59
Appendix G ........................................................................................................... 60
Appendix H ........................................................................................................... 61
Appendix I ........................................................................................................... 62
Appendix J ........................................................................................................... 64

References ........................................................................................................... 65
# List of Tables

<table>
<thead>
<tr>
<th>Table No.</th>
<th>Table Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Underwood's Point Scale</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Rating System for Team Point Differences and Average Team Efficiency Rating Difference</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>Correlation Coefficients (r) for Correlations 1 and 2</td>
<td>45</td>
</tr>
</tbody>
</table>
List of Figures

<table>
<thead>
<tr>
<th>Figure No.</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Correlation coefficients of points to efficiency ratings for each team</td>
<td>37</td>
</tr>
<tr>
<td>2</td>
<td>Correlation coefficients of points to efficiency ratings comparing the women's and men's populations to the total sample</td>
<td>39</td>
</tr>
<tr>
<td>3</td>
<td>Correlation coefficients of minutes played to efficiency ratings for each team</td>
<td>41</td>
</tr>
<tr>
<td>4</td>
<td>Correlation coefficients of minutes played to efficiency ratings comparing the women's and men's populations to the total sample</td>
<td>43</td>
</tr>
<tr>
<td>5</td>
<td>Correlation coefficients of team/opponent point differences to average team/opponent efficiency rating differences</td>
<td>47</td>
</tr>
</tbody>
</table>
CHAPTER 1

Introduction

It is 7:00 AM, the day after the big basketball game. Sports fans all over the nation pick up the morning newspaper and turn to the sports page to review the events of last night's game. They immediately locate the game's box score and quickly scan the lines to find out how the teams performed and how their favorite players played.

The box score statistics available to the sports fans give a detailed summary of the game. A typical basketball box score in the newspaper includes the following individual statistics: individual players' minutes played, field goals made and attempted, 3 point field goals made and attempted, free throws made and attempted, total points scored, rebounds, assists, steals, blocked shots and personal fouls. There is also a complete listing of team statistics: team totals for points scored per quarter and by game, shots taken and shots made, rebounds, assists, steals, blocked shots and personal fouls. Sometimes, the box score notes each team's individual high performer(s) for each statistic recorded. Sports fans, with the aid of the box score, have a wealth of information available about the game and, with a quick glance, can evaluate the performance of a team or player.

The attention these statistics will receive has just begun, because not only do sports fans analyze box score statistics, but the coaching staff does also. The coach or coaching staff will spend more time analyzing the box score statistics and may even have additional statistics taken during the game. Coaches keep a detailed record of the statistics for each player and track running totals of all the statistics available for the
entire season. Coaches, forever in pursuit of the most successful team they can assemble, use these statistics to make decisions about their players.

The official NCAA box score sheet (see Appendix A) is an example of the type of information a coach receives from the sports information director after each game. This form includes numerous statistics on individual players for each game of the season and include:

- field goals made
- field goals attempted
- 3 point field goals made
- 3 point field goals attempted
- free throws made
- free throws attempted
- offensive and defensive rebounds
- personal fouls
- total points
- assists
- turnovers
- blocked shots
- steals
- minutes played

Running totals for the season are kept for all the statistics included in the box scores. Other individual statistics which a coach requests per game and totalled per season may include:

- field goal percentage
- 3 point field goal percentage
- free throw percentage
- average rebounds
- average points scored
- average minutes played
- which players fouled out
- number of games started
- number of games played
- shot locations
Team and opponent statistics are also important. Team totals per game and per season are kept for all the statistics within the box score sheet as well as team highs and team lows. The same box score statistics, individual and team, may also be collected for opponents.

According to Wilkes (1982), coaches analyze data on their team as well as their opponents for many reasons. By analyzing individual performances, coaches attempt to understand the strengths and weaknesses of the players which form their team. The strengths can be noted and praised and areas which need attention in future practice sessions can be pinpointed. This knowledge of mistakes can be an excellent guide for pointing out offensive and defensive weaknesses. If the performance of individual players can be improved, the coach can field a better team. By analyzing opponents, a coach may become aware of opponent's individual and team strengths, weaknesses and tendencies and plan game strategies accordingly. Statistics, therefore, are a valuable tool available to coaches in performing their job.

The knowledge the coaches gain from analyzing box score statistics assists them in forming performance objectives based on the weaknesses noted from game statistics. Performance objectives, with set criteria, can be developed to: continually improve the performance of the team, motivate individuals and teams as they strive to achieve their goals and also determine if success has been achieved. Individuals can evaluate their own progress and direct their efforts in the most effective direction based on the performance objectives the coach has set as well as personal goals.

In analyzing individual performance, a coach hopes to evaluate players according to
their overall performance. This can be a difficult task for the coach because there are many facets of the game at which a player can excel. For example, an individual can be a great rebounder but also commit numerous turnovers. Therefore, the coach has to compare performance statistics to decide which players have the greatest overall positive contribution to the team. In the hope of fielding the team which will maximize the performance of the players, the coach can rely on the results of an efficiency rating system which is based directly on the overall performance of each player.

A basketball efficiency rating system uses mathematical operations, in the form of a formula, and box score statistics, as inputs to the formula, to place a numerical value on the overall performance of a player. For each statistic available in the box score, an individual can be awarded positive or negative points toward their overall efficiency rating. These points are then combined in the efficiency rating formula to give the coach a numerical value for each player. The numerical value is the efficiency rating and can be used as a direct comparison of the players' performances.

The efficiency rating system is an excellent way to evaluate player performance because it is an objective process of evaluation and provides player feedback. Intangible aspects, such as intensity, effort or defensive play are eliminated from the evaluation and all the data used to calculate the efficiency ratings are actual events occurring during the game. The efficiency rating makes it easier for the coaches to rank the players according to overall performance. The player with the highest efficiency rating is ranked first and the player with the lowest efficiency rating is ranked last. The efficiency rating system is flexible in that the formula can be varied to represent the coach's philosophy and the variables in the formula are independently weighted. Incentives can also be built into the efficiency rating system. For example, a player can be awarded bonus points for
performances the coach thinks are exceptional. Therefore, an efficiency rating system is important to the basketball coach and can be an integral tool in the analysis of the performance of a team.

Ideally, an efficiency rating system is an objective and quantitative measure of individual and team performance. It can be used to analyze opponents, evaluate their performance and attempt to predict the outcome of the game. If every team used an identical efficiency rating system, team efficiency ratings could be compared prior to and after a game. The pre-game analysis could be used as a predictor of game outcome and the post-game analysis could be used to validate the efficiency rating system. Did the team with the best efficiency rating win the game? The efficiency rating can also be used to assist the coaches in shaping or modifying their game plan to win the game. If an efficiency rating system can be helpful to the coach, then why not search for the best efficiency rating?

The best efficiency rating must be valid, reliable and objective. In this investigation, the author tests the validity, reliability and objectivity of Smith's (1983) efficiency rating scale. Validity is determined by comparing a player's efficiency rating results to the number of points scored and the number of minutes an athlete plays. Validity can also be measured by comparing the average team efficiency rating to whether the team won or lost the game. Reliability is tested by repeatedly comparing the three variables to the efficiency rating using a large data sample. Objectivity is achieved by eliminating any subjectivity in the efficiency rating formula and in attempting to correlate the variables to the efficiency rating by use of the Pearson Product Moment Correlation Coefficient. An efficiency rating must be tested and found valid, reliable and objective before it can be used successfully.
Statement of the Problem

The purpose of this investigation was to determine whether the basketball efficiency rating system developed by Smith (1983) is a valid method of evaluating individual player's performance and predicting game outcome.

Hypothesis

The hypothesis of this investigation is that Smith's (1983) efficiency rating scale is a valid method of evaluating an individual player's performance and predicting game outcome.

Significance of the Investigation

There are a number of efficiency ratings available to coaches. Chapter Two contains a discussion about a variety of efficiency ratings which were found in books, periodicals and magazines. The author chose to investigate Smith's (1983) efficiency rating system for three reasons. The first and most unique element of the efficiency rating is it considered how many minutes a player played in the game. This normalized each player's efficiency rating to one game. For example, without considering minutes played in Smith's (1983) formula, player A and player B could have the same efficiency rating. Player A played the entire game (40 minutes) and player B only half the game (20 minutes). Player B achieved an equivalent efficiency rating in half the time as player A and obviously was the more efficient player. Smith's (1983) efficiency rating divides the
rating value by the percentage of the game each player played. Therefore, player B would reflect a greater efficiency rating than player A when minutes played were included into Smith's (1983) formula.

The second reason for choosing Smith’s (1983) efficiency rating system is that it has built in goals within the formula. Smith awards bonus points for performances which meet these goals. For example, a player is awarded one point for each assist, plus one bonus point for each assist greater than three. Thus, a player can strive to meet the built in standards for each variable included in the efficiency rating system and improve his/her performance.

The third reason for using Smith’s (1983) efficiency rating system is the adaptability of the efficiency rating system to the computer. The use of computers has a number of potential benefits. The ideal use would be for a coach to receive a print out of the available box score statistics and efficiency ratings any time during a game. Important decisions about the game plan, based on the statistics and efficiency rating results, can be made. This may possibly change the outcome of the game and identify events relating to game outcome.

Virtually, any computer with spreadsheet capabilities can be used to calculate a basketball efficiency rating. An efficiency rating is a formula and formulas lend themselves easily to computer use, especially in the format of a spreadsheet. The author used a Packard Bell, Legend IV, 286, IBM compatible computer. The software used was the Microsoft Excel spreadsheet. The spreadsheet format was created by the author and the efficiency rating formula was programmed into the computer. The box score data was entered into the computer in the format of the spreadsheet and the efficiency rating for each player was calculated. The printout includes the box score data
and the calculated efficiency rating (see Appendix B).

As coaches develop more sophisticated efficiency rating systems which require more computation, the computer becomes even more attractive. It can save time and accurately tabulate the needed results. A complete, organized printout of the results is likely to be available immediately after the data has been entered into the computer.

This quick process provides a coach with more time to analyze the results and develop a true picture of each player's performance. Computers also act as a filing cabinet to store and retrieve data with minimal effort. They can provide flexibility to the user and, as efficiency ratings change, so can the programs. A user can customize or modify the program to meet the needs of the coaching staff. Computers are becoming readily available at all levels of sports programs and their benefits are widespread.

Delimitations

1. This investigation is delimited to college age men and women.

2. This investigation is delimited to the sport of basketball.

Limitations

1. This investigation is limited to the:
- Syracuse University's 1990-'91 men's collegiate basketball team, players and opponents.

2. The efficiency rating scale to be evaluated in this investigation is Smith's (1983) efficiency rating system. A minimum of 10 minutes playing time is needed to calculate an efficiency rating.

3. The basketball game statistics were collected by the State University of New York, College at Brockport's, the University of Rochester's and Syracuse University's Sports Information Director or statisticians.

4. Intensity and defensive play were two elements of Smith's (1983) original efficiency rating system which were excluded from the formula for this investigation because they were subjective evaluations of player performance. Thus, only objective measures were used in this investigation.

5. The statistics received from Brockport's women's team, the University of Rochester and Syracuse University did not include the statistic of charges taken which is a part of Smith's (1983) efficiency rating system. Therefore, charges taken were eliminated from the efficiency rating formula for the State University of New York, College at Brockport, women's teams, the University of Rochester men's team and their opponents and Syracuse University men's team and their opponents.

6. Brockport men's and women's teams did not consistently provide complete box score statistics for the opposing teams, and therefore, efficiency ratings
were not calculated for Brockport's opponents.

**Definition of Terms**

**Assist** - a player is credited with an assist when a player makes, in the judgement of the statistician, the principal pass contributing directly to a field goal (or an awarded score of two or three points) (NCAA, 1991).

**Charge** - a push by a player against an opponent in a legal position (Krause, 1983) or
   (1) (Men) a common foul committed by a player while he is in control of the ball.
   (2) (Women) a common foul committed by a player while she is in control of the ball or by an airborne shooter (NCAA, 1987).

**Charge taken** - the player who the charge was drawn on.

**Efficiency Rating System** - a type of performance evaluation which places a numerical value on the overall performance of an athlete.

**Field goal attempt (FGA)** - charged to a player any time the player shoots, throws or taps a live ball at his or her own basket, when, in the opinion of the statistician, the player is attempting to score a goal, with these exceptions. A FGA is not charged if:
   - the player is fouled in the act of shooting and the goal is not made.
   - there is offensive goaltending or offensive basket interference on that shot.
- a shot is taken near the expiration of time for a period, is not made, and it is
the statistician's opinion that the shot was a desperation shot and not a
reasonable attempt to make a field goal (NCAA, 1991).

**Field goal made** - credited to a player any time a FGA by a player results in the goal
being counted or results in an awarded score of two or three points except when the field
goal is the result of a defensive player tipping the ball in the offensive basket (NCAA, 1991).

**Free throw attempt (FTA)** - charged any time a player shoots a free throw and there is
no violation (or technical for goaltending) during the throw, with these exceptions:

(a) an attempt as well as a free throw made is credited if the shot is made
and there is a violation by the defense.

(b) an attempt is charged if the only penalized violation is for failure of the
throw to touch the rim (NCAA, 1991).

**Free throw made** - credited to a player any time a FTA by that player results in the
throw being counted or results in an awarded score of one point (NCAA, 1991).

**Objectivity** - the degree to which different testers can achieve the same scores on the
same subjects (Thomas & Nelson, 1985).

**Performance** - a temporary event of executing an action which can be achieved through
motivation, learning and development (M. Colby, personal communication, July, 1993).
**Personal Foul** - illegal contact with an opponent while the ball is alive or after the ball is in possession of a player for a throw-in. Contact after the ball has become dead is ignored for men and women unless it is intentional, flagrant or during a throw-in or, for women only, when the contact is committed by an airborne shooter (NCAA, 1987).

**Rebound (offensive or defensive)** - an individual rebound is credited to a player who recovers a live ball that has missed scoring a goal (field goal or free throw). The recovery may be accomplished by:

- gaining control of the ball.
- tipping or batting the ball in an attempt to score a goal.
- tipping or batting the ball to a teammate so that the teammate or another teammate is the first to gain control.
- retrieving a rebound simultaneously with an opposing player and having his or her own team be the first to be entitled to the ball (NCAA, 1991).

**Reliability** - the degree of consistency or repeatability of a test or measure (Thomas & Nelson, 1985).

**Scouting report** - a summary and analysis of the opponents strengths and weaknesses which may include offensive and defensive styles of play and characteristics of individual players.
**Steal** - credited to a player when the player's positive aggressive action(s) causes a turnover by an opponent. This may be accomplished by:

(a) taking the ball away from an opponent in control of the ball.

(b) getting a hand on the ball in control of an opponent and causing a held ball to be called, and having his or her team be awarded the ball for a throw-in.

(c) batting a ball in control of an opponent to a teammate.

(d) batting a ball in control of an opponent away from the opponent and out of bounds.

(e) intercepting an opponent's pass.

(f) deflecting an opponent's pass to a teammate.

(g) deflecting an opponent's pass away from an opponent and out of bounds (NCAA, 1991).

**Turnover** - occurs when a team, after gaining control of the ball or having been entitled to the ball, does not put a live ball in flight for a try for goal (field or free) that would count if it goes in, before the opponent either gains control of the ball, is entitled to the ball or scores a goal (Exception: If the failure to put the ball in flight for a try is due to the expiration of time, no turnover is charged.)(NCAA, 1991).

**Validity** - the degree to which a test measures what it is intended to measure (Kirkendall, Gruber and Johnson, 1980).
CHAPTER 2

Review of Literature

**Nature and Use of Performance Evaluations**

Performance evaluations are used by many people in different forms to assist in determining effectiveness, productivity and learning. A few examples of performance evaluations are:

- performance scales developed to evaluate teacher effectiveness.
- tests given to students to evaluate strengths and weaknesses, determine the amount of progress and assess a student in relation to peers.
- performance appraisals used by employers to calculate productivity and determine wage levels.

These different types of evaluation procedures assist in judging the performance of a person.

In the sport of basketball, outperforming the opponent is needed to win a game. Therefore, basketball coaches are continually evaluating player performance. Performance evaluations or basketball efficiency rating scales were developed in an attempt to place a numerical value on performance. This assessment procedure allows a coach to compare one athlete to another. The numerical value is based on the box score statistics collected during a game and gives one value to a player’s overall performance.

In an attempt to develop a valid basketball efficiency rating system, factors which
influence performance need to be identified. Research has already begun in determining which aspects of the basketball game are most important in forming a successful team.

Underwood (1985) developed a basketball player performance evaluation which attempted to incorporate all aspects of a player's performance. A point scale was designed to award positive or negative points for scorebook statistics. Table 1 displays the statistics which were considered important and each player was awarded points for each statistic collected. The points were totalled to numerically reflect a player's actual contribution, which is more realistic than skimming the scorebook or reviewing charts and making subjective evaluations.

If Underwood's (1985) system is understood by the players, it can be a valuable coaching tool in providing meaningful feedback to the athletes. The disadvantages of the performance evaluation is that it does not consider a large portion of defensive play and a player's team role may not enable them to score well on the performance evaluation. For example, a point guard whose role is to bring up the ball, set up the play and defend against the fast break does not have the opportunity to score well on Underwood's performance evaluation.
Table 1

**Underwood's Point Scale**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Points Value per Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field goals made</td>
<td>+1.3</td>
</tr>
<tr>
<td>Free throws made</td>
<td>+.7</td>
</tr>
<tr>
<td>Rebounds - offensive</td>
<td>+1.2</td>
</tr>
<tr>
<td>Rebounds - defensive</td>
<td>+1</td>
</tr>
<tr>
<td>Assists</td>
<td>+.7</td>
</tr>
<tr>
<td>Defensive possession</td>
<td>+1</td>
</tr>
<tr>
<td>Blocked shots</td>
<td>+.5</td>
</tr>
<tr>
<td>Foul - no shot</td>
<td>+.5</td>
</tr>
<tr>
<td>Field goals missed</td>
<td>-.8</td>
</tr>
<tr>
<td>Free throws missed</td>
<td>-.8</td>
</tr>
<tr>
<td>Turnovers</td>
<td>-1</td>
</tr>
<tr>
<td>Fouls - personal</td>
<td>-.7</td>
</tr>
<tr>
<td>Fouls - technical</td>
<td>-2</td>
</tr>
<tr>
<td>Tie-ups</td>
<td>-.5</td>
</tr>
</tbody>
</table>
Pete Herrman (1985) evaluated his players' game performances and allowed them to see how well they performed for the whole game. The numerical value for game performance is computed by adding up all the positive box score statistics and subtracting all the negative box score statistics. The positive points include field goals and free throws made, rebounds, assists, steals, forced turnovers and blocked shots when possession is gained. Missed field goals and free throws, personal and technical fouls and turnovers compose the negative points. Each positive and negative statistic is weighted equally with one point awarded for each statistic. This simple evaluation gives each player a quick overview of total game performance.

Taylor (1986) utilizes a post-game summary report. This supplement to the scouting report contains a review of the important strategies of both teams and describes the attempted adjustments of the game. It includes recording the defensive matchups, a summary of the game, keys or significant factors relating to game outcome, adjustments which did and did not work, things to do next time and a practice plan for the next game. Player performance is evaluated and adjustments are made for improvement. This helps the coach understand why the team performed as it did.

Objective player performance evaluations are beneficial to the total team. Seasonal figures identify the strengths and weaknesses of the players, aid the coach in making judgements on what strategies to use in the game, act as motivators to increase player performance and provide useful information for goal setting. All of these factors can make the difference in terms of adding to the success of the team.
Importance of Basketball Statistics

Most coaches use some type of charting as a helpful coaching tool to measure and analyze player performances. Accurate records can reveal vital information about the strength and weaknesses of players. MacAdam (1984) discusses three reasons for recording statistics. First, they measure performance in indicated areas the coach considers as important. The second reason is that they help the coach understand what is happening during the game, and lastly they can be a powerful motivator to improve player performance.

On the other hand, statistics can be misleading if not recorded and evaluated correctly. They may not always show the true picture of the performance and may not necessarily be the best measure of total performance in a particular skill area. Deciding which statistics best measure the players' performance which contribute to a successful outcome can be a puzzling problem to coaches.

Pim (1982) studied 316 basketball games played in five Division 1 conferences to discover which statistical factors were most important in determining the winning and losing teams in college basketball. Data involving fifteen statistical variables were obtained from all the Atlantic Coast, Big East, Big Ten, Southwest Athletics and Western Athletic conference games from the 1978 season. The fifteen variables investigated included:

- points scored
- field goals made
- field goals attempted
- personal fouls
- assists
- turnovers
All the variables except turnovers showed a significant difference between winning and losing basketball teams. Pim (1982) found five variables which best differentiated between winning and losing teams for all five conferences combined: field goal percentages, free throws attempted, total rebounds, personal fouls and half-time lead.

When the conferences were treated singularly, Pim (1982) found three variables which best differentiated between winning and losing teams and they included field goal percentages, total rebounds and personal fouls. Therefore, improving field goal percentages, rebounding techniques and the ability to draw personal fouls should be emphasized during practice sessions.

McDonald (1985) recommends team statistics over individual statistics as the formula for success. Examples of team statistics include the number of passes per possession, number of times the team brought the ball across half-court and did not get a shot, number of team offensive rebounds and number of times possession was regained after a turnover without an opposing score. Players work on executing the fundamental skills and must play together to win. The recording of team statistics focuses on how well the team performs as one unit. This can alleviate the problem of players struggling within a team to be the star statistical performer.

The key to statistics, according to MacAdam (1984), is what the coach does with
them after the game. Adapting statistics to the coach's philosophy and using them regularly serve as a starting point for game discussions. Comments can be made on specific aspects of the game and the statistics can serve as a reference to performance in a particular area. This can help the team and coach better evaluate the performances in the game and contribute to success.

Use of Computers in Sports Statistics

As a result of the availability of microcomputers in physical education and sport settings and the increasing need to collect and tabulate data, more professionals are becoming literate in the use of computers. Statistics play an important role in evaluating player performances in the competitive basketball world, so why not use a computerized basketball statistics program to obtain, tabulate, process and print out game results? Today, it is much easier for coaches to turn in that direction.

There are many advantages for using computers in analyzing sport statistics and Stein (1984) recognized three. Computers have the capability to store and retrieve large amounts of data with speed and accuracy; are easily accessible and available; and are continually decreasing in cost to come within budget limits. The advantages, described by Frazier and Hatfield (1984), include ridding a coach of the tedious task of computing statistics, identifying players who are most productive and having the capability to store and retrieve a variety of statistics for the entire year, game or season-to-date totals with relative ease.

As computer use increases, basketball statistics programs are becoming more readily available. Frazier and Hatfield (1984) note other available programs which predict
what a person's statistics would have been if he/she had played the entire game. It also ranks players under each statistic, analyzes player performance, gives defensive effectiveness reports, provides the coach with information about every line up combination used in a game and evaluates players on a percentage scale.
CHAPTER 3

Methodology

The purpose of this investigation was to determine whether Smith's (1983) basketball efficiency rating system was a valid method of evaluating individual player's performance. Twelve seasons of basketball box score data were collected from the sports information directors at three universities: State University of New York, College at Brockport, University of Rochester and Syracuse University. Efficiency ratings were calculated for qualifying players for all the games of the twelve seasons. Then three correlations were used to validate the efficiency rating system. The validation consisted of correlating the individual's points scored to the individual's efficiency rating, the individual's minutes played to the individual's efficiency rating and total team point difference to average team efficiency rating difference.

The methods section is divided into four sub-headings: subjects, data collection, description and calculation of efficiency rating, and correlation coefficient.

Subjects

teams.

**Description and Calculation of Efficiency Rating**

Once the appropriate data were collected and entered into the computer, the efficiency rating system developed by Smith (1983) was implemented. The investigator developed a computer spreadsheet using Smith's (1983) formula to compute the efficiency ratings. For all the teams in this investigation, the efficiency ratings were calculated for each qualifying individual in each game. A qualifying individual is a player playing a minimum of ten minutes in the game.

Efficiency rating equation (see Appendix E):

\[
\text{Efficiency rating} = \text{field goal pts} + \text{free throw pts} + \left( \frac{\text{rebound pts} + \text{assist pts} + \text{charges pts} + \text{turnover pts} + \text{foul pts}}{\text{minutes played x .025}} \right)
\]

Intensity and defense were two variables which the investigator deleted from the efficiency rating formula because it was a subjective evaluation given by the coaching staff at the end of each game. This type of data is not part of the NCAA box scores and was not available. Deleting these variables also eliminated any chance of coaching staff
biases from the efficiency rating.

Smith (1983) computed each variable in the formula in the following manner:

**Rebound Points** = One point for each rebound and steal plus one bonus point for each rebound + steal greater than 5. (Example: 7 rebounds + steals = 9 points)

**Assist Points** = One point for each assist plus one bonus point for each assist greater than 3. (Example: 9 assists = 15 points)

**Charge Points** = Number of charges taken x 5. (Example: 2 charges = 10 points)

**Turnover Points** = One negative point for each turnover plus one additional negative point for each turnover greater than 3. (Example: 5 turnovers = -7 points)

**Foul Points** = One negative point for each personal foul accumulated. Add one negative point for fouling out. (Example: 5 fouls = -6 points)

**Field Goal Points** = 10 x adjusted field goal %. Adjusted field goal % is field goal % + 3 bonus points for each % point above 50%.

(Example #1: 55% field goal percentage = .55 + (.05 x 3) = .70 (adjusted field goal %) = 7 points).

Subtract 3 points for each % point below 50%.

(Example #2: 40% field goal percentage = .40 - (.10 x 3) = .10 (adjusted field goal %) = -3 points).
goal %) = 1 point)

*Field goal % = the number of field goals made divided by the number of field goals attempted.

Free Throw Points = \( \frac{(10 \times \text{adjusted free throw %})}{2} \). Adjusted free throw % is free throw %* plus 3 bonus points for each % point above 70%.

(Example #1: 80% free throw percentage = .80 + (.10 \times 3) = 1.10 \) (adjusted free throw %) \times 10 = 11 = 11 / 2 = 5.5 points).

Subtract 3 points for each % point below 70%.

(Example #2: 55% free throw percentage = .55 - (.15 \times 3) = .10 \) \) (adjusted free throw %) \times 10 = 1 = 1 / 2 = .5 points)

*Free throw % = the number of free throws made divided by the number of free throws attempted.

For a sample calculation of an individual's efficiency rating see Appendix F.

The efficiency rating system gives each player a numerical value at the end of each game. The numerical value is derived from the individual box score statistics reported by the statisticians. The investigator used the individual statistics to compute the points for each item in the formula. Each player received positive points for positive statistics and negative points for negative statistics. The efficiency ratings were then computed.

In Smith's (1983) efficiency rating, each variable was weighted according to the goals set by the team. Smith weighted each variable in the efficiency formula according to these goals.
Smith's (1983) formula awarded bonus points to each player who has a field goal percentage greater than the team goal of 50%. Likewise, points were subtracted for each percentage point less than 50%. This gave the players bonus points when their field goal percentage was above 50%. The team goal for free throw percentage was 70%. Bonus points were also awarded to the players who achieve this goal and points were subtracted for each percentage point below 70%.

Rebounds and steals are important factors because the team gains possession of the ball which is essential in scoring a basket. They were combined to calculate rebound points. One bonus point was awarded for each rebound plus steal greater than 5. This number was chosen by Smith (1983) because it was considered a significant contribution.

Assists lead to the scoring of points. If a player achieved more than 3 assists, one bonus point per assist greater than 3 was awarded to the player.

Charges taken was the only statistic which is a part of Smith's (1983) efficiency rating system and was not readily available from the Official NCAA box score sheet (see Appendix A). Each charge taken was awarded 5 points. This statistic was weighted heavily because possession of the ball goes to the non-charging team. In addition, a charge taken shows good defensive positioning, eliminates the opposition's chance to score and also adds a foul to an opposing player and their team total. This may possibly send a player to the free throw line to score points. It also has a psychological affect on the charging player because the player may be afraid to commit another charge while driving to the basket.

Both turnovers and fouls show negative performance and therefore negative points were given. One negative point was given for each turnover and one additional negative
point was given for each turnover greater than 3. Likewise, one negative point was given for each foul and one additional negative point was given for fouling out of the game.

The team goal was to have a minimal number of turnovers and fouls. The less turnovers and fouls a player receives during a game, the less negative points given out.

Minutes played was the final statistic needed to calculate the efficiency ratings. Each NCAA game consists of 40 minutes. Minutes played was multiplied by .025 in order to normalize all player's statistics to a per game basis. For example:

- 40 minutes played x .025 = 1 (played the entire game)
- 30 minutes played x .025 = .75 (played 75% of the game)
- 20 minutes played x .025 = .50 (played 50% of the game)

This prorated each player's statistics to the percentage of the game which he/she played. A minimum of ten minutes playing time was needed to calculate an efficiency rating.

This ten minute period of time was an arbitrary number chosen by Smith (1983) to be an accurate representation of a player's performance. The more minutes a person plays the more valid the representation of statistics. Rebound, assist, charge, turnover and foul points are directly related to minutes played and therefore were divided by the minutes factor.

Correlation Coefficient

In attempting to validate the efficiency rating formula, three correlations were analyzed. The correlations determined the relationship between the following factors:
1. Individual points scored per game ($X$) and individual efficiency ratings per game ($Y$).

This correlation was analyzed because points scored per game is a measure of offensive performance and gives each player a numerical rating. The investigator determined the relationship between the numerical points scored and the calculated numerical efficiency rating.

One correlation coefficient ($r$) was calculated pairing each qualifying player's points scored ($X$) to their efficiency rating ($Y$) for each game that all twelve teams played. A qualifying player must play ten or more minutes in a game. Correlation coefficients were also calculated using subsets of the total database. The subsets included calculating correlation coefficients for each of the twelve teams individually, the women's teams only and the men's teams only. A total of fifteen correlation coefficients ($r$) were calculated and compared.

2. Individual minutes played per game ($X$) and individual efficiency ratings ($Y$).

Coaches evaluate athletes and play their most effective players in order to win a game. Therefore, this correlation was chosen to determine if the most efficient athletes received more playing time.

One correlation coefficient ($r$) was calculated pairing each qualifying player's minutes played per game ($X$) to their efficiency rating ($Y$) for each game that all twelve teams played. A qualifying player must play ten or more minutes in a game. Correlation coefficients were also calculated using subsets of the total database. The subsets
included calculating correlation coefficients for each of the twelve teams individually, the women's teams only and the men's teams only. A total of fifteen correlation coefficients \((r)\) were calculated and compared.

3. Game outcomes or team point differences \((X)\) and average team efficiency rating differences \((Y)\).

Game outcome is the ultimate test for this evaluation tool. The best performing team should win the game. This correlation was done only for Syracuse University and the University of Rochester men's teams and their opponents because the box score statistics were not consistently available for the Brockport teams opponents. Therefore, home and opponent efficiency ratings could not be calculated and compared for Brockport. For the purpose of this investigation, the author referred to the University of Rochester and Syracuse University as the home teams. The difference between the home team's total points and the opponent team's total points were calculated for each game of the season. The average team efficiency rating differences between the home team and opponent were also calculated for each game. A rating system was set up to place a numerical value or score on the differences in total points and the differences in average team efficiency ratings (refer to Table 2 for the rating system). A larger score would correspond to a larger difference. A negative score represents Syracuse University or the University of Rochester scoring fewer points than their opponent or having a smaller average team efficiency rating than their opponent.
A correlation coefficient was calculated for each team's season by pairing the two scores given for team point difference and average team efficiency rating difference. This resulted in two correlation coefficients, one for the 1991-92 University of Rochester men's season and the other for the 1990-91 Syracuse University men's season. A third correlation coefficient was calculated by combining the University of Rochester's and Syracuse University's data. The three correlation were then compared.
Table 2

**Rating System for Team Point Differences and Average Team Efficiency Rating**

<table>
<thead>
<tr>
<th>Point Difference per Game</th>
<th>Average Team Efficiency Rating Difference per Game</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>61 to 70</td>
<td>60.01 to 70</td>
<td>7</td>
</tr>
<tr>
<td>51 to 60</td>
<td>50.01 to 60</td>
<td>6</td>
</tr>
<tr>
<td>41 to 50</td>
<td>40.01 to 50</td>
<td>5</td>
</tr>
<tr>
<td>31 to 40</td>
<td>30.01 to 40</td>
<td>4</td>
</tr>
<tr>
<td>21 to 30</td>
<td>20.01 to 30</td>
<td>3</td>
</tr>
<tr>
<td>11 to 20</td>
<td>10.01 to 20</td>
<td>2</td>
</tr>
<tr>
<td>1 to 10</td>
<td>.01 to 10</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>-1 to -10</td>
<td>-.01 to -10</td>
<td>-1</td>
</tr>
<tr>
<td>-11 to -20</td>
<td>-10.01 to -20</td>
<td>-2</td>
</tr>
<tr>
<td>-21 to -30</td>
<td>-20.01 to -30</td>
<td>-3</td>
</tr>
<tr>
<td>-31 to -40</td>
<td>-30.01 to -40</td>
<td>-4</td>
</tr>
<tr>
<td>-41 to -50</td>
<td>-40.01 to -50</td>
<td>-5</td>
</tr>
<tr>
<td>-51 to -60</td>
<td>-50.01 to -60</td>
<td>-6</td>
</tr>
<tr>
<td>-61 to -70</td>
<td>-60.01 to -70</td>
<td>-7</td>
</tr>
</tbody>
</table>
This investigation was suitable to application of the Pearson Product Moment Correlation. The computation of the Pearson correlation coefficient (symbolized by r) is shown in Equation 2:

$$r = \frac{N \sum XY - (\Sigma X)(\Sigma Y)}{\sqrt{N \sum X^2 - (\Sigma X)^2} \sqrt{N \sum Y^2 - (\Sigma Y)^2}}$$  \hspace{1cm} (2)

- \(N\) = number of paired scores
- \(\Sigma\) = summation of scores
- \(X, Y\) = raw scores of two variables

Once the relationships between the variables were determined, the correlation coefficient was interpreted. The investigator chose 2 ways to interpret the results. They were:

1. The correlation coefficient expressed as an r-value. In this investigation the perfect correlation is +1.00 meaning one variable was completely associated with the other.

2. Consulting a table. The table used was the Critical Values of Correlation Coefficients table (Kirk, 1978). The .05 level of significance for a two-tailed test was chosen.
This investigation examined the basketball efficiency rating system developed by Smith (1983) and attempted to determine whether it was a valid method of evaluating individual player's performance and predicting game outcome. In this chapter, the results of the investigation are presented and statistically interpreted. The following statistical tools were used to analyze the data:

1. Pearson Product Moment Correlation Coefficient.
2. Critical Values of Correlation Coefficient Table (Kirk, 1978).

Three correlations were analyzed using the Pearson product moment correlation coefficient. They included:

1. Individual points scored to individual efficiency ratings.
2. Individual minutes played to individual efficiency ratings.
3. Game outcome (team point difference) to average team efficiency rating difference.

Correlations 1 and 2 included the data collected from:

- State University of New York, College at Brockport men's and women's

- University of Rochester men's collegiate basketball team and their opponents for the 1991-92 season.
- Syracuse University men's collegiate basketball team and their opponents for the 1990-1991 season.

Correlation 3 analyzed the data from the University of Rochester 1991-92 men's and Syracuse University 1990-91 men's collegiate basketball teams and their opponents. Brockport's data was not used in correlation 3 because it did not consistently include the opponents box scores and therefore home and opponent efficiency ratings could not be calculated and compared.

In this chapter, the data from correlations 1 and 2 are displayed in four forms. Three of the four forms were subsets of the total sample of data. The fourth form was the total sample of data. The data samples included:

A. Calculating a correlation coefficient (r) for each of the twelve team's seasons (12 r-values).
B. Calculating a correlation coefficient (r) for the women's games only (1 r-value).
C. Calculating a correlation coefficient (r) for the men's games only (1 r-value).
D. Calculating a correlation coefficient (r) for all the teams' data combined (1 r-value).
Correlation 1

Individual Points Scored per Game to Individual Efficiency Ratings per Game

Calculating correlation coefficients (r) of individual points scored per game (X) to individual efficiency ratings per game (Y) for the 12 teams (A).

Correlation 1, individual points scored per game to individual efficiency ratings per game, utilized the variables in Appendix G for each of the twelve teams to calculate twelve correlation coefficients. The X and Y variables were derived from summing the individual qualifying players’ points per game (X) and summing the individual qualifying players’ efficiency ratings per game (Y) for each team’s season.

Figure 1 shows the results of calculating the correlation coefficient (r) for the twelve teams’ seasons using the Pearson product moment correlation coefficient formula (see Equation 2 in Chapter 3). The variables for each calculation of r are listed in Appendix G (Team # 1 through # 12) and the results were the correlation coefficients for the twelve teams.

Using the Critical Values of the Pearson r table (Kirk, 1978), the twelve correlations were significant at the .01 level for a two-tailed test. This seems to indicate that there is a significant relationship between individual points scored and individual efficiency ratings.
Figure 1. Correlation coefficients ($r$) of individual points scored per game ($X$) to individual efficiency ratings per game ($Y$) for each team.

Note. Team #1: $N = 218$, Team #2: $N = 230$, Team #3: $N = 240$, Team #4: $N = 244$, Team #5: $N = 161$, Team #6: $N = 170$, Team #7: $N = 186$, Team #8: $N = 148$, Team #9: $N = 178$, Team #10: $N = 152$, Team #11: $N = 175$, Team #12: $N = 157$. 
Calculating correlation coefficients (r) of individual points scored per game to individual efficiency ratings per game for the women's population (B), the men's population (C) and the total data sample (D).

The two subsets of data were created, women and men, to determine if either population sample differed greatly in correlation coefficients from the total sample of data.

In correlating individual points scored per game (X) to individual efficiency ratings per game (Y), Appendix G (the sum of lines # 9 through # 12) shows the variables used in calculating the Pearson product moment correlation coefficient (see Equation 2) for the women's teams. Summing lines # 1 through # 8 in Appendix G show the variables used in Equation 2 to calculate the men's teams' correlation coefficient (r). A third correlation coefficient was calculated for the total data sample using Equation 2 and the variables from line # 13 of Appendix G. This correlation was the combination of all the teams' seasons. The correlation coefficient for the women's and men's population samples were compared to the correlation coefficient for the total sample of data and are shown in Figure 2.

The relationship between individual points scored per game and individual efficiency ratings per game for the women's, men's and total population samples were positive correlations (r = .47, r = .54, r = .53). These results, according to the Critical Values of the Pearson r table (Kirk, 1978), are significant at the .01 level of significance for a two-tailed test. This appears to indicate there is a significant relationship between points scored and Smith's (1983) efficiency rating and can be generalized to both women's and men's teams.
Figure 2. Correlation coefficients ($r$) of individual points scored per game ($X$) and individual-efficiency ratings per game ($Y$) comparing the women's and men's sample populations to the total sample.

Note. At the .01 level of significance for a two-tailed test and 500 degrees of freedom, the critical value of $r$ is .115.
Correlation 2

Individual Minutes Played per Game to Individual Efficiency Ratings per Game

Correlation coefficients comparing individual minutes played per game to individual efficiency ratings per game for the twelve teams' seasons (A).

Individual minutes played per game correlated to individual efficiency ratings per game was the second correlation. Appendix H shows the variables used to calculate the correlation coefficient for each of the twelve teams in the data sample. The $X$ and $Y$ variables for each team's season were derived from the sum of the qualifying players' minutes played per game and the sum of the qualifying players' efficiency ratings per game, respectively.

Figure 3 shows the correlation coefficients for the twelve teams' seasons using Equation 2 in Chapter 3 and variables in Appendix H (# 1 through # 12). The correlation coefficients of individual minutes played per game to individual efficiency ratings per game were lower than the first correlation (individual points scored per game to individual efficiency ratings per game).

After referencing the Critical Values of Pearson $r$ table to determine significance, the author found the results to be significant for all teams except Team # 8. Team # 11 was significant at the .05 level of significance for a two-tailed test. Teams # 4 and # 12 were significant at the .02 level of significance for a two-tailed test. Teams # 1, # 2, # 3, # 5, # 6, # 7, # 9, and # 10 were all significant findings at the .01 level of significance for a two-tailed test.
**Figure 3.** Correlation coefficient (r) of individual minutes played per game (X) to individual efficiency ratings per game (Y) for each team's season.

![Chart showing correlation coefficients for different teams]

**Note.** Team #1: \( N = 218 \), Team #2: \( N = 230 \), Team #3: \( N = 240 \), Team #4: \( N = 244 \), Team #5: \( N = 161 \), Team #6: \( N = 170 \), Team #7: \( N = 186 \), Team #8: \( N = 148 \), Team #9: \( N = 178 \), Team #10: \( N = 152 \), Team #11: \( N = 175 \), Team #12: \( N = 157 \).
Calculating correlation coefficients of individual minutes played per game to individual efficiency ratings per game for the women's population (B), the men's population (C) and the total sample of data (D).

Three more correlation coefficients comparing individual minutes played per game to individual efficiency ratings per game were calculated. They included the women's population sample, the men's population sample and the total sample of the population. The sum of lines #9 through #12 in Appendix H and the sum of lines #1 through #8 in Appendix H show the variables used to calculate the correlation coefficient for the women's population and the men's population, respectively. The variables in line #13 of Appendix H were used to calculate a correlation coefficient for the total population sample. See Figure 4 for the comparison of correlation coefficients for the three population samples.

A positive correlation coefficient was the result of the data samples for the women's, men's and total populations ($r = .29$, $r = .27$, $r = .27$). Looking at the large number of paired scores for the data samples used in this investigation, this is a significant finding. At the .01 level of significance for a two-tailed test and 500 degrees of freedom ($N - 2$), $r$ must be .115 or greater to be significant. This criteria was met for all three data samples and therefore can be generalized to women's and men's populations.
Figure 4. Correlation coefficients ($r$) of individual minutes played per game ($X$) to individual efficiency ratings per game ($Y$) comparing the women's and men's sample populations to the total sample.
Table 3 summarizes the results of the correlation coefficients ($r$) for correlations 1 and 2 for each of the data samples. Correlation 1 compares individual points scored per game to individual efficiency ratings per game. Correlation 2 compares individual minutes played per game to individual efficiency ratings per game.
<table>
<thead>
<tr>
<th>Team</th>
<th>N</th>
<th>Correlation 1</th>
<th>Correlation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pts. to effic.</td>
<td>min. to effic.</td>
</tr>
<tr>
<td>Team # 1</td>
<td>218</td>
<td>.60</td>
<td>.23</td>
</tr>
<tr>
<td>Team # 2</td>
<td>230</td>
<td>.62</td>
<td>.41</td>
</tr>
<tr>
<td>Team # 3</td>
<td>240</td>
<td>.63</td>
<td>.21</td>
</tr>
<tr>
<td>Team # 4</td>
<td>244</td>
<td>.30</td>
<td>.14</td>
</tr>
<tr>
<td>Team # 5</td>
<td>161</td>
<td>.62</td>
<td>.43</td>
</tr>
<tr>
<td>Team # 6</td>
<td>170</td>
<td>.57</td>
<td>.33</td>
</tr>
<tr>
<td>Team # 7</td>
<td>186</td>
<td>.54</td>
<td>.28</td>
</tr>
<tr>
<td>Team # 8</td>
<td>148</td>
<td>.48</td>
<td>.09</td>
</tr>
<tr>
<td>Team # 9</td>
<td>178</td>
<td>.65</td>
<td>.43</td>
</tr>
<tr>
<td>Team # 10</td>
<td>152</td>
<td>.57</td>
<td>.42</td>
</tr>
<tr>
<td>Team # 11</td>
<td>175</td>
<td>.27</td>
<td>.15</td>
</tr>
<tr>
<td>Team # 12</td>
<td>157</td>
<td>.38</td>
<td>.19</td>
</tr>
<tr>
<td>Women</td>
<td>662</td>
<td>.47</td>
<td>.29</td>
</tr>
<tr>
<td>Men</td>
<td>1597</td>
<td>.54</td>
<td>.27</td>
</tr>
<tr>
<td>Total</td>
<td>2259</td>
<td>.53</td>
<td>.27</td>
</tr>
</tbody>
</table>
Appendix I shows the scores received per game by the University of Rochester men's basketball team and Syracuse University men's basketball team for the team/opponent point differences and average team/opponent efficiency rating differences. The $X$ and $Y$ variable scores are based on the rating system in Table 2 of Chapter 3. The variables listed in Appendix J were used to compute correlation coefficients for Syracuse University, the University of Rochester and the combination of both teams' data. The $X$ and $Y$ variables listed for Syracuse University and the University of Rochester in Appendix J are the sums of the Point Difference ($X$) column and the Efficiency Rating Difference ($Y$) column for the thirty-one games in Appendix I.

Figure 5 represents the correlation coefficient of team/opponent point differences and average team/opponent efficiency rating differences. The results were significant in all three data samples. Using the Critical Values of the Pearson $r$ table, Figure 5 shows $N = 31$, $N = 31$ and $N = 62$ for the University of Rochester, Syracuse University and the combination of the two seasons respectively. Therefore, at 29 degrees of freedom ($N - 2$) and the .01 level of significance, $r = .456$ is the critical value and at 60 degrees of freedom ($N - 2$), $r = .325$ is the critical value. Referring to Figure 5, one can assume team/opponent point differences has a strong relationship to team/opponent efficiency rating differences.
Figure 5. Correlation coefficients ($r$) of team/opponent point difference ($X$) to average team/opponent efficiency rating difference ($Y$).

S. U. -91 is the 1990-1991 Syracuse University men's basketball team.
Combined is the result of combining the U. of R.-92 and S. U.-91 basketball teams.

Note.
CHAPTER 5

Summary

The purpose of this investigation was to determine whether Smith's (1983) basketball efficiency rating system was a valid method of evaluating an individual player's performance and predicting game outcome.


Efficiency ratings were calculated for qualifying players from the box score data received from the sports information directors at each university. A qualifying player is a player playing ten or more minutes in the game.

Three correlations were analyzed to determine the relationship between the following variables:

1. Individual points scored per game and individual efficiency ratings per game.
2. Individual minutes played per game and individual efficiency ratings per game.
3. Team/opponent point differences and team/opponent average efficiency rating differences.

By comparing the three correlations, Smith's efficiency rating system was tested for validity. Within this attempt to validate the efficiency rating system, reliability and
objectivity were also tested and achieved. The author used a variety of data samples and received the same results, supporting the rating's reliability. Subjective evaluations within the efficiency rating formula were eliminated to achieve objectivity. Therefore, reliability and objectivity, as well as validity were tested.

In this investigation, two statistical tools were used to analyze the results of the three correlations. They included:

1. Pearson Product Moment Correlation Coefficient (r).
2. Critical Values of Correlation Coefficient Table (Kirk, 1978).

Conclusions

The following conclusions can be made from this investigation:

1. There seems to be a greater positive relationship between points scored and Smith's (1983) efficiency rating than between minutes played and Smith's (1983) efficiency rating.

2. There appears to be a significant relationship between end of game point differences and end of game average team efficiency rating differences. Therefore, the author assumes an end of game efficiency rating comparison between opposing teams is a good indication of game outcome.

3. Smith's (1983) efficiency rating system seems to be a valid, reliable and objective
method of placing a numerical value on players' performances. This takes into account a combination of box score statistics.

Recommendations

Further research is needed to develop the most accurate performance evaluation tool in the sport of basketball. A numerical rating system can aid a coach in his/her coaching decisions and motivate an athlete to improve performance. Recommendations for further research include:

1. Correlate evaluation tools or efficiency rating systems used by other coaches with the efficiency rating system developed by Smith (1983) for the same data sample.
2. Correlate efficiency ratings to each statistic recorded in a box score sheet to see which statistic or statistics best represents the numerical efficiency rating system.
3. In replicating this investigation, the author suggests using a larger data sample for correlating team/opponent point differences to average team/opponent efficiency rating differences to determine whether the findings can be generalized to larger populations.
4. Correlate team/opponent point differences to total team/opponent efficiency rating differences.
5. Change the weighting of variables in Smith's efficiency rating system (1983) and correlate the two efficiency ratings.
6. Develop a user friendly computer program to calculate efficiency ratings as the statistics are being recorded. Use the efficiency rating output to predict game outcome prior to the end of the game.
Appendix A

**Official NCAA Basketball Box Score Sheet**

<table>
<thead>
<tr>
<th>Team 1</th>
<th>Team 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>Score</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

...
OFFICIAL NCAA BASKETBALL BOX SCORE

VISITORS (Last name, first) (Indicate starters by position or with an asterisk) Starting Time

<table>
<thead>
<tr>
<th>No.</th>
<th>Team</th>
<th>FG</th>
<th>FGa</th>
<th>FG%</th>
<th>FT</th>
<th>FTA</th>
<th>TP</th>
<th>FT%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TEAM REBOUNDS (Included in Totals)

TOTALS

TOTAL FG%: 1st half 2nd half Game
3-PT FG%: 1st half 2nd half Game
FT%: 1st half 2nd half Game

HOME (Last name, first) (Indicate starters by position or with an asterisk)

<table>
<thead>
<tr>
<th>No.</th>
<th>Team</th>
<th>FG</th>
<th>FGa</th>
<th>FG%</th>
<th>FT</th>
<th>FTA</th>
<th>TP</th>
<th>FT%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TEAM REBOUNDS (Included in Totals)

TOTALS

TOTAL FG%: 1st half 2nd half Game
3-PT FG%: 1st half 2nd half Game
FT%: 1st half 2nd half Game

Technical fouls: Score by PERIOD 1ST H 2ND H OT FINAL

Attendance:

Officials:

NCAA 8860-9/92
Appendix B

Sample Printout of Box Score Data, Efficiency Rating Calculations and Correlation Coefficient Calculations
## Box Scores 2/18/92

Brockport (83) vs. Geneseo (76) Home

<table>
<thead>
<tr>
<th>PL</th>
<th>2FG</th>
<th>2FGA</th>
<th>3FG</th>
<th>3FGA</th>
<th>FT</th>
<th>FTA</th>
<th>R</th>
<th>PF</th>
<th>TP</th>
<th>A</th>
<th>TO</th>
<th>Blk</th>
<th>S</th>
<th>Min</th>
<th>Ch</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>#2</td>
<td>8</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>19</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>#3</td>
<td>12</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>28</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>#4</td>
<td>5</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>16</td>
<td>9</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>39</td>
<td>0</td>
</tr>
<tr>
<td>#5</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>#6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>#7</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>#8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Efficiency Rating Calculations

**Brockport vs. Geneseo**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>-15.00</td>
<td>0.00</td>
<td>3.00</td>
<td>1.00</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
<td>-13.00</td>
<td>7</td>
</tr>
<tr>
<td>#2</td>
<td>9.62</td>
<td>-0.50</td>
<td>15.00</td>
<td>1.00</td>
<td>2.00</td>
<td>3.00</td>
<td>0.00</td>
<td>21.01</td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td>13.24</td>
<td>9.50</td>
<td>11.00</td>
<td>0.00</td>
<td>1.00</td>
<td>3.00</td>
<td>0.00</td>
<td>31.77</td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>9.00</td>
<td>-0.50</td>
<td>9.00</td>
<td>15.00</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
<td>30.04</td>
<td></td>
</tr>
<tr>
<td>#5</td>
<td>2.78</td>
<td>-0.50</td>
<td>7.00</td>
<td>5.00</td>
<td>3.00</td>
<td>3.00</td>
<td>0.00</td>
<td>8.59</td>
<td></td>
</tr>
<tr>
<td>#6</td>
<td>25.00</td>
<td>9.50</td>
<td>2.00</td>
<td>0.00</td>
<td>2.00</td>
<td>2.00</td>
<td>0.00</td>
<td>34.50</td>
<td></td>
</tr>
<tr>
<td>#7</td>
<td>11.67</td>
<td>0.00</td>
<td>2.00</td>
<td>3.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>22.33</td>
<td></td>
</tr>
<tr>
<td>#8</td>
<td>0.00</td>
<td>-10.50</td>
<td>1.00</td>
<td>0.00</td>
<td>2.00</td>
<td>1.00</td>
<td>0.00</td>
<td>na</td>
<td></td>
</tr>
</tbody>
</table>

Team Average 19.32
Pearson Product Moment Correlation Coefficient

Brockport vs. Geneseo

Points (X) & Final Effic. (Y)

<table>
<thead>
<tr>
<th>Player</th>
<th>Pts (X)</th>
<th>Final Effic. (Y)</th>
<th>X^2</th>
<th>Y^2</th>
<th>XY</th>
<th>N=</th>
<th>r=</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>0.00</td>
<td>-13.00</td>
<td>0.00</td>
<td>169.00</td>
<td>0.00</td>
<td>7</td>
<td>0.59</td>
</tr>
<tr>
<td>#2</td>
<td>19.00</td>
<td>21.01</td>
<td>361.00</td>
<td>441.31</td>
<td>399.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td>28.00</td>
<td>31.77</td>
<td>784.00</td>
<td>1009.18</td>
<td>889.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>16.00</td>
<td>30.04</td>
<td>256.00</td>
<td>902.31</td>
<td>480.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#5</td>
<td>9.00</td>
<td>8.59</td>
<td>81.00</td>
<td>73.85</td>
<td>77.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#6</td>
<td>7.00</td>
<td>34.50</td>
<td>49.00</td>
<td>1190.25</td>
<td>241.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#7</td>
<td>4.00</td>
<td>22.33</td>
<td>16.00</td>
<td>498.78</td>
<td>89.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#8</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sum</td>
<td>83.00</td>
<td>135.24</td>
<td>1547.00</td>
<td>4284.67</td>
<td>2177.42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Minutes (X) & Final Effic. (Y)

<table>
<thead>
<tr>
<th>Player</th>
<th>Min (X)</th>
<th>Final Effic. (Y)</th>
<th>X^2</th>
<th>Y^2</th>
<th>XY</th>
<th>N=</th>
<th>r=</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>20</td>
<td>-13.00</td>
<td>400.00</td>
<td>169.00</td>
<td>-260.00</td>
<td>7</td>
<td>0.11</td>
</tr>
<tr>
<td>#2</td>
<td>37</td>
<td>21.01</td>
<td>1369.00</td>
<td>441.31</td>
<td>777.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td>31</td>
<td>31.77</td>
<td>961.00</td>
<td>1009.18</td>
<td>984.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>39</td>
<td>30.04</td>
<td>1521.00</td>
<td>902.31</td>
<td>1171.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#5</td>
<td>38</td>
<td>8.59</td>
<td>1444.00</td>
<td>73.85</td>
<td>326.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#6</td>
<td>17</td>
<td>34.50</td>
<td>289.00</td>
<td>1190.25</td>
<td>586.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#7</td>
<td>15</td>
<td>22.33</td>
<td>225.00</td>
<td>498.78</td>
<td>335.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#8</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sum</td>
<td>197.00</td>
<td>135.24</td>
<td>6209.00</td>
<td>4284.67</td>
<td>3921.62</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C

Team Labels

1. S.U.-91 is Syracuse University Men's 1990-91 basketball team.
2. S.U. Opp-91 is the opponents of Syracuse University Men's 1990-91 basketball team.
5. Br-M-89 is State University of New York, College at Brockport Men's 1988-89 basketball team.
7. Br-M-91 is State University of New York, College at Brockport Men's 1990-91 basketball team.
11. Br-W-91 is State University of New York, College at Brockport Women's 1990-91 basketball team.
Appendix D

Obtaining Data from Author

The game by game box score statistics for the 1990-91 Syracuse University men's basketball team and their opponents, the 1991-92 University of Rochester men's basketball team and their opponents and the four seasons of the State University of New York, College at Brockport men's and women's teams can be supplied upon requested from the author of this investigation through the institution listed below:

c/o Dr. Dan Smith
State University of New York, College at Brockport
Department of Physical Education and Sport
Brockport, New York 14420
(716) 395-5330
Basic Formula:

\[
\frac{\text{intensity} + \text{defense}}{2} + \text{field goal pts} + \text{free throw pts} + \\
\frac{\text{rebound pts} + \text{assist pts} + \text{charges pts} + \text{turnover pts} + \text{foul pts}}{\text{minutes played} \times 0.025}
\]

How Each Item Is Obtained:

**INTENSITY & DEFENSE** = Subjective evaluation by the coaches (10 point scale)

**REBOUND + STEAL** = Add one bonus point for each rebound + steal greater than 5 (Ex. 7 rebounds + steals is worth 9 points)

**ASSISTS** = Add one bonus point for each assist greater than 3 (Ex. 9 assists is worth 15 points)

**CHARGES** = Number of charges taken x 5

**FIELD GOAL POINTS** = 10 x adjusted F.G. %. Adjusted F.G. % = Add 3 bonus points for each % point above .50. Subtract 3 bonus points for each % point below .50. (Ex. 55% = 70 = 7 points) (Ex. 40% = 10 = 1 point)

**FREE THROW POINTS** = 10 x adjusted F.T. % / 2. Adjusted F.T. % = Add 3 bonus points for each % point above .70. Subtract 3 bonus points for each % point below .70. (Ex. 80% = 110 = 11 / 2 = 5.5) (Ex. 55% = 1 / 2 = .5)

**TURNOVERS** = Add one negative point for each turnover greater than 3. (Ex. 5 turnovers = -7 points)

**PERSONAL FOULS** = One negative point for each foul. Add one for fouling out. (Ex. 5 fouls = -6 points)

**NOTE:** A MINIMUM OF 10 MINUTES PLAYING TIME IS NEEDED FOR AN EFFICIENCY RATING.
Appendix F

Sample Calculation of an Individual Efficiency Rating

Subject #1 - data from box scores

Field goal made = 5
Field goals attempted = 8
Field goal % = 5 / 8 = .63 = 63%
Free throws made = 10
Free throws attempted = 13
Free throw % = 10 / 13 = .77 = 77%
Total rebounds = 2

Steals = 2
Personal fouls = 2
Total points = 22
Assists = 4
Turnovers = 4
Charges taken = 0
Minutes played = 33

Field goal points = 10 x [.63 + (.63 - .50) x 3] = 10.2
Free throw points = [10 x (.77 + (.77 - .70) x 3)] / 2 = 4.9
Rebound points = 2 + 2 + 0 = 4
Foul points = 2
Assist points = 4 + (4 - 3) = 5
Turnover points = (4 + (4 - 3)) = 5
Charge points = 0 x 5 = 0
Efficiency Rating = 10.2 + 4.9 + ((4 + 5 + 0 - 5 - 2) / (33 x .025))

= 17.51
Appendix G

Variables of Correlation Coefficient (r) for Individual Points Scored per Game (X) and Individual Efficiency Ratings per Game (Y)

<table>
<thead>
<tr>
<th>Team</th>
<th>Points (X)</th>
<th>Effic. (X)</th>
<th>X²</th>
<th>Y²</th>
<th>XY</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. U. - 91</td>
<td>2564</td>
<td>3267</td>
<td>44994</td>
<td>108225</td>
<td>56106</td>
<td>218</td>
</tr>
<tr>
<td>S. U. Opp - 91</td>
<td>2191</td>
<td>1912</td>
<td>32673</td>
<td>63938</td>
<td>32889</td>
<td>230</td>
</tr>
<tr>
<td>U. of R. - 92</td>
<td>2254</td>
<td>3568</td>
<td>33002</td>
<td>108910</td>
<td>49717</td>
<td>240</td>
</tr>
<tr>
<td>U. of R. Opp - 92</td>
<td>1716</td>
<td>1893</td>
<td>20358</td>
<td>95057</td>
<td>21021</td>
<td>244</td>
</tr>
<tr>
<td>Br - M - 89</td>
<td>1880</td>
<td>2040</td>
<td>30462</td>
<td>65522</td>
<td>35262</td>
<td>161</td>
</tr>
<tr>
<td>Br - M - 90</td>
<td>1736</td>
<td>1579</td>
<td>26014</td>
<td>63199</td>
<td>27653</td>
<td>170</td>
</tr>
<tr>
<td>Br - M - 91</td>
<td>1902</td>
<td>2076</td>
<td>27482</td>
<td>63050</td>
<td>30977</td>
<td>186</td>
</tr>
<tr>
<td>Br - M - 92</td>
<td>1675</td>
<td>2106</td>
<td>26309</td>
<td>60642</td>
<td>31037</td>
<td>148</td>
</tr>
<tr>
<td>Br - W - 89</td>
<td>1405</td>
<td>1401</td>
<td>18611</td>
<td>70049</td>
<td>24753</td>
<td>178</td>
</tr>
<tr>
<td>Br - W - 90</td>
<td>1306</td>
<td>1419</td>
<td>16338</td>
<td>49279</td>
<td>19883</td>
<td>152</td>
</tr>
<tr>
<td>Br - W - 91</td>
<td>1399</td>
<td>1525</td>
<td>18991</td>
<td>69559</td>
<td>17602</td>
<td>175</td>
</tr>
<tr>
<td>Br - W - 92</td>
<td>1191</td>
<td>767</td>
<td>14855</td>
<td>40146</td>
<td>11400</td>
<td>157</td>
</tr>
<tr>
<td>Sum</td>
<td>21219</td>
<td>23555</td>
<td>309997</td>
<td>857615</td>
<td>358500</td>
<td>2259</td>
</tr>
</tbody>
</table>
Appendix H

Variables of Correlation Coefficients (r) for Individual Minutes Played per Game (X) and Individual Efficiency Ratings per Game (Y)

<table>
<thead>
<tr>
<th>Team</th>
<th>Min</th>
<th>Effic.</th>
<th>X²</th>
<th>Y²</th>
<th>XY</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>(X)</td>
<td>Rtg (Y)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. S. U. - 91</td>
<td>6072</td>
<td>3267</td>
<td>188704</td>
<td>108225</td>
<td>98939</td>
<td>218</td>
</tr>
<tr>
<td>2. S. U. Opp - 91</td>
<td>5801</td>
<td>1912</td>
<td>166639</td>
<td>63938</td>
<td>61088</td>
<td>230</td>
</tr>
<tr>
<td>3. U. of R. - 92</td>
<td>6073</td>
<td>3568</td>
<td>172291</td>
<td>108910</td>
<td>97072</td>
<td>240</td>
</tr>
<tr>
<td>4. U. of R. Opp - 92</td>
<td>5855</td>
<td>1893</td>
<td>158389</td>
<td>95097</td>
<td>50831</td>
<td>244</td>
</tr>
<tr>
<td>5. Br - M - 89</td>
<td>4429</td>
<td>2040</td>
<td>133379</td>
<td>65522</td>
<td>65283</td>
<td>161</td>
</tr>
<tr>
<td>6. Br - M - 90</td>
<td>4629</td>
<td>1579</td>
<td>135269</td>
<td>63199</td>
<td>50075</td>
<td>170</td>
</tr>
<tr>
<td>7. Br - M - 91</td>
<td>4869</td>
<td>2076</td>
<td>139273</td>
<td>63050</td>
<td>60522</td>
<td>186</td>
</tr>
<tr>
<td>9. Br - W - 89</td>
<td>4515</td>
<td>1401</td>
<td>128691</td>
<td>70049</td>
<td>47976</td>
<td>178</td>
</tr>
<tr>
<td>10. Br - W - 90</td>
<td>4263</td>
<td>1419</td>
<td>132181</td>
<td>49279</td>
<td>48831</td>
<td>152</td>
</tr>
<tr>
<td>11. Br - W - 91</td>
<td>4252</td>
<td>1525</td>
<td>116018</td>
<td>69559</td>
<td>40948</td>
<td>175</td>
</tr>
<tr>
<td>13. Sum</td>
<td>59006</td>
<td>23555</td>
<td>1720502</td>
<td>857615</td>
<td>705679</td>
<td>2259</td>
</tr>
</tbody>
</table>
Appendix I

Rating system scores for team/opponent point differences (X) and average team/opponent efficiency rating differences (Y) per game

<table>
<thead>
<tr>
<th>Game</th>
<th>Pt. Diff.</th>
<th>Effic. Rtg</th>
<th>X²</th>
<th>Y²</th>
<th>XY</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>(X)</td>
<td>Diff. (Y)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>3</td>
<td>16</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>2</td>
<td>16</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>2</td>
<td>25</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>3</td>
<td>25</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>2</td>
<td>15</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Game</th>
<th>Pt. Diff.</th>
<th>Effic. Rtg</th>
<th>X²</th>
<th>Y²</th>
<th>XY</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>(X)</td>
<td>Diff. (Y)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>-1</td>
<td>1</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>3</td>
<td>25</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>3</td>
<td>25</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

(table continues)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(x)</td>
<td>Diff. (y)</td>
<td>$x^2$</td>
<td>$y^2$</td>
</tr>
<tr>
<td>14</td>
<td>-1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>-1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>22</td>
<td>5</td>
<td>2</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>23</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>25</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>26</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>28</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>-2</td>
<td>-1</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Variables of correlation coefficients for team/opponent point differences and average team/opponent efficiency rating differences

<table>
<thead>
<tr>
<th>Team</th>
<th>Point Diff. (X)</th>
<th>Effic. Rtg. Diff. (Y)</th>
<th>$X^2$</th>
<th>$Y^2$</th>
<th>$XY$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syracuse University</td>
<td>43</td>
<td>27</td>
<td>133</td>
<td>83</td>
<td>88</td>
<td>31</td>
</tr>
<tr>
<td>University of Rochester</td>
<td>60</td>
<td>45</td>
<td>198</td>
<td>97</td>
<td>123</td>
<td>31</td>
</tr>
<tr>
<td>Sum =</td>
<td>103</td>
<td>72</td>
<td>331</td>
<td>180</td>
<td>211</td>
<td>62</td>
</tr>
</tbody>
</table>
References


