# Exploring the Influence of Commonly Cited Statistics on NCAA Basketball Team Efficiency Using Data Envelopment Analysis

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# Overview

1) Sports and Service
2) Data Envelopment Analysis (DEA)
3) DEA model used
4) Data
5) Results
6) Conclusions
7) Current Research

# Who cares about sports?




- In 2009-10, the National Federation of State High School Associations (NFHS) reported that more than 7.6 million American high school students played sports (~55% of all high school students)
- Academic institutions are **not-for-profit,** so all revenue generated by the sports programs is funneled back into the athletics or academic programs of the institution




**"Show me the money" – Jerry Maguire**

- 2008-2009 overall annual revenue for all college sports was ~$10.6 **billion**
- In 2010, 49,670,895 attended NCAA football games (all divisions)
- In 2011, $256.6 million dollars was bet on college and professional basketball
- In 2011, 25,147,122 people attended Division I NCAA men's basketball games
  - In 2011, the average NBA player's salary was $5.15 million a year
  - The five most profitable NBA teams averaged $37 million in profit over the last five seasons

The sheer scope of college and professional athletics warrants effective utilization of their resources.



# Sports service




What is Service?

- ***noun*** "the supplying or supplier of utilities or commodities, as water, electricity, or gas, required or demanded by the public"
- ***adjective*** "supplying aids or services rather than products or goods"

Sports provide a visual and emotional experience

- A key part for sports service operations management is to enhance the overall experience of those paying for the service (McMahon-Beattie and Yeoman, 2004).





Service businesses are one of many domains for the application of management science tools to improve the efficiency and effectiveness of operations.

# Data Envelopment Analysis (DEA)

1978 - "**Measuring the efficiency of decision making units,**" appeared in EJOR by Charnes, Cooper and Rhodes

- The goal is to measure production efficiency by empirically estimating non-parametric production frontiers via linear programming.

In other words,

- determine which decision making units (DMUs) are most efficient based on their levels of input and output compared to the entire set of DMUs

**Advantages**

1. Requires few assumptions and does not require any functional forms
2. Can have multiple inputs and outputs
3. Has been proven to be useful in uncovering relationships that remain hidden for other methodologies

**Disadvantages**

1. the number of efficient DMUs on the frontier tends to increase with the number of inputs and output variables
2. results can be sensitive to the selection of inputs and outputs
3. you cannot test for the best specification

# DEA Models

These 3 models investigate the inefficiency of DMUs to the corresponding production frontier.

1) Input-oriented = reducing the inputs as much as possible whereby sustaining the current level of production
2) Output-oriented = maximizing the output level(s) while not surpassing the observed input consumption
3) Additive/Slack-based (SBM) = tackle both output deficits and input glut simultaneously

**Why an output-oriented model?**

- collegiate basketball management (i.e. athletics directors, coaches, or other higher level administration) will strategically focus on maximizing their wins, while not necessarily focusing on minimizing costs.

- the primary goal of most high growth businesses and the consistent short-term hiring and firing of collegiate basketball coaches due to lack of winning suggests output-oriented is most appropriate in this context (Belzer, 2012).



# Two-stage Output-Oriented VRS DEA Model

**Stage 1**

$$\max \theta$$

Subject to:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \qquad i = 1,..,m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \leq \theta y_{r0} \qquad r = 1,..,s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

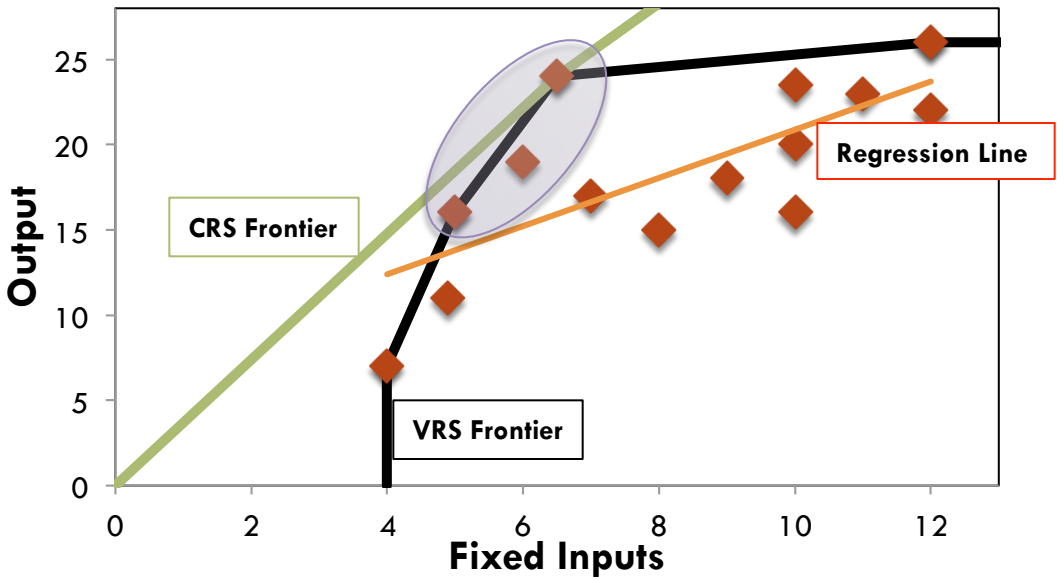
$$\lambda_j \geq 0 \qquad j = 1,..,n$$

**Note:**
$\theta = efficiency\ of\ DMU_0$
$n = \#\ of\ DMUs$
$m = \#\ of\ Inputs$
$s = \#\ of\ Outputs$

**Ideas:**

- Goal is to increase the current level of output while keeping the inputs the same
- Allows us to project any inefficient DMU (team) as a weighted convex combination of similar teams on the performance frontier (see oval below)

**Output-Oriented VRS vs. CRS Frontiers**

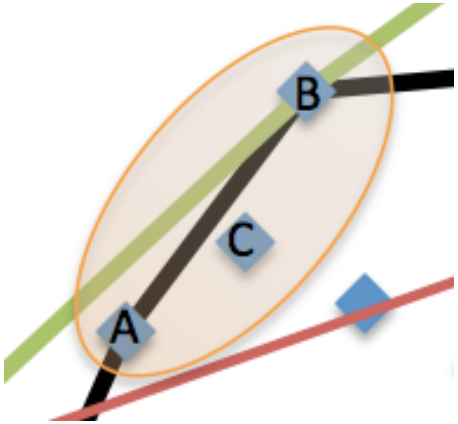


# Two-stage Output-Oriented VRS DEA Model

1) Run model n times (once per DMU)

**Why?**

We must determine if we can find a set of weights so that a convex combination of them will perform better than just one of them.




$$\max \theta$$

Subject to:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0} \qquad i = 1,..,m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \leq \theta y_{r0} \qquad r = 1,..,s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad j = 1,..,n$$

**Note:**
$\theta = efficiency\ of\ DMU_0$
$n = \#\ of\ DMUs$
$m = \#\ of\ Inputs$
$s = \#\ of\ Outputs$

**What if we find a convex combination?**

That DMU is inefficient

**If we don't?**

That DMU is efficient, thus on the DEA frontier

# Data - Teams

- 2011-2012 college basketball season
- 345 Division I Men's basketball teams
  - Because of the heterogeneity, we only used 127 teams (11 conferences)

  **Team inclusion criteria**: Came from a conference that had:

  1. averaged at least $1 million in men's basketball revenue
  2. averaged a strength of schedule of at least .500
  3. had an average winning percentage of at least .500

| Conference | Number of Teams | Minimum Revenue | Average Revenue | Average Profit | Average PythSOS | Average Winning % |
|---|---|---|---|---|---|---|
| Big Ten | 12 | $6,371,843 | $12,638,477 | $6,827,720 | 0.722 | 0.616 |
| ACC | 12 | $5,535,773 | $10,872,896 | $4,841,122 | 0.634 | 0.574 |
| Big East | 16 | $3,977,728 | $10,453,340 | $3,635,620 | 0.683 | 0.599 |
| SEC | 12 | $6,914,565 | $10,314,879 | $3,454,235 | 0.655 | 0.596 |
| Big 12 | 10 | $5,448,009 | $9,506,630 | $3,153,612 | 0.691 | 0.603 |
| Pac 12 | 12 | $3,717,501 | $7,595,855 | $2,683,199 | 0.604 | 0.556 |
| Mountain West | 8 | $1,689,770 | $4,326,916 | $1,105,418 | 0.554 | 0.624 |
| Atlantic 10 | 14 | $1,905,562 | $4,070,811 | $1,051,007 | 0.617 | 0.543 |
| CUSA | 12 | $1,405,994 | $3,157,407 | ($14,850) | 0.558 | 0.555 |
| Missouri Valley | 10 | $1,445,143 | $2,631,211 | $138,927 | 0.593 | 0.539 |
| Horizon | 10 | $1,022,407 | $1,979,553 | ($41,491) | 0.510 | 0.503 |

# Data – Inputs and Outputs

| Variables | Description |
|---|---|
| AdjOffEff | Adjusted Offensive Efficiency |
| AdjDefEff | Adjusted Defensive Efficiency |
| AdjTempo | Adjusted Tempo: The number of possessions per 40 minutes. |
| Avg Hgt | Average Height: Average listed height of every player on the team, weighted by minutes played. |
| Bench Minutes | Bench minutes: Assumes starters five are players who played the most minutes on the season. |
| Off 3PA% | Offensive 3-Point Field Goal Attempted Percentage |
| Def 3PA% | Defensive 3-Point Field Goal Attempted Percentage, but for opposing team |
| Def FT% | Defensive Free-Throw Percentage: Free throw percentage for opponents played |
| Experience | Experience: Number of years of college experience determined by a player's eligibility class. |
| Off FT Rate | Offensive Free Throw Rate: Measures a player's ability to get the line relative to how often he attempts to score. |
| Def FT Rate | Defensive Free Throw Rate: Same as offensive free throw rate, but for opposing team |
| Off eFG% | Offensive Effective Field Goal Percentage: Same as regular field goal percentage, except that made three-pointers are appropriately given 50% more credit. |
| Def eFG % | Defensive Effective Field Goal Percentage: Same as Off eFG%, but for opposing team |
| Off TO% | Offensive Turnover Percentage: Turnovers divided by possessions. |
| Off OR% | Offensive Offensive Rebounding Percentage: The number of possible offensive rebounds a player gets. The denominator is scaled based on the percentage of a team's minutes played by the player. |
| PythSOS | Pythagorean Strength of Schedule |
| NCSOS | Non-Conference Pythagorean Strength of Schedule |
| Total Staff | Total Staff: Total number of head coaches, assistant coaches, part-time staff, etc. |
| Rev/Exp | Revenue/Expenses: Ratio of revenues to expenses for the entire season |
| Win% | Won-Lost Percentage |

- Other basketball DEA studies such as (Cooper et al., 2009) analysis of efficiency of the Spanish Basketball league, used variables such as adjusted free throw %, rebounds, assists, and steals

- Our basketball DEA incorporated these typical metrics plus other relevant input features of the college game:
  1. kenpom.com statistics - commonly cited in media to evaluate team performance
     - Mike Kryzewski (Duke), Brad Stevens (Butler), and many others coaches have been cited as using this data for game preparation
  2. financial and team resource statistics (Department of Education Office of Postsecondary Education )

# Efficient conferences

- All Horizon and Missouri Valley teams were found to be 100% efficient, meaning they can't improve their winning % given their current resources
- The Big Ten and ACC are considered two of the most talented basketball conferences and have the highest % of inefficient teams

| Conference | No. 100% Eff. | No. teams | Pct. of teams 100% Eff. |
|---|---|---|---|
| Horizon | 10 | 10 | 100.0% |
| Missouri Valley | 10 | 10 | 100.0% |
| Big East | 15 | 16 | 93.8% |
| Conference USA | 11 | 12 | 91.7% |
| Big 12 | 9 | 10 | 90.0% |
| SEC | 10 | 12 | 83.3% |
| Pac 12 | 9 | 12 | 75.0% |
| Mountain West | 6 | 8 | 75.0% |
| Atlantic 10 | 10 | 14 | 71.4% |
| ACC | 8 | 12 | 66.7% |
| Big Ten | 8 | 12 | 66.7% |

# Inefficient Teams

- This table shows the 21 inefficient teams, their efficiency, and relative weights $\lambda_j$

| Inefficient Teams | | Best-Practices Team Reference Set | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DMU Name | O-O VRS Eff. | Team1 | Team2 | Team3 | Team4 | Team5 | Team6 | Team7 | Team8 | Team9 |
| Arizona | 1.08688 | 0.0532 | 0.0037 | 0.0036 | 0.2713 | 0.5922 | 0.0004 | 0.0669 | 0.0087 | |
| Arizona St. | 1.74559 | 0.3291 | 0.0294 | 0.2388 | 0.3285 | 0.0742 | | | | |
| Charlotte | 1.24896 | 0.2468 | 0.2181 | 0.0050 | 0.1454 | 0.0338 | 0.0203 | 0.3306 | | |
| Dayton | 1.21850 | 0.2185 | 0.1429 | 0.2705 | 0.1025 | 0.1043 | 0.0787 | 0.0827 | | |
| East Carolina | 1.26899 | 0.1677 | 0.0093 | 0.0709 | 0.1092 | 0.0187 | 0.1141 | 0.4504 | 0.0399 | 0.0198 |
| Illinois | 1.09021 | 0.1308 | 0.0693 | 0.2541 | 0.2665 | 0.0154 | 0.1708 | 0.0804 | 0.0071 | 0.0056 |
| Indiana | 1.06573 | 0.2585 | 0.1980 | 0.2000 | 0.2970 | 0.0464 | | | | |
| Iowa St. | 1.10090 | 0.2866 | 0.2446 | 0.1731 | 0.2127 | 0.0261 | 0.0570 | | | |
| Maryland | 1.18176 | 0.1924 | 0.0180 | 0.0999 | 0.0162 | 0.0088 | 0.4751 | 0.1448 | 0.0448 | |
| Miami FL | 1.17818 | 0.0459 | 0.1955 | 0.1314 | 0.2379 | 0.0348 | 0.1871 | 0.0596 | 0.0767 | 0.0309 |
| Minnesota | 1.18320 | 0.1321 | 0.0954 | 0.2218 | 0.2555 | 0.2952 | | | | |
| North Carolina St. | 1.12590 | 0.0986 | 0.4932 | 0.1494 | 0.0072 | 0.0012 | 0.2505 | | | |
| Penn St. | 1.11181 | 0.0482 | 0.2273 | 0.0822 | 0.0679 | 0.0103 | 0.2903 | 0.1153 | 0.1003 | 0.0583 |
| Rhode Island | 1.90618 | 0.0224 | 0.2202 | 0.1458 | 0.1353 | 0.4499 | 0.0221 | 0.0043 | | |
| St. Bonaventure | 1.18929 | 0.1659 | 0.0588 | 0.1575 | 0.3368 | 0.2810 | | | | |
| Tennessee | 1.08522 | 0.0009 | 0.1436 | 0.0854 | 0.0359 | 0.0921 | 0.3505 | 0.1844 | 0.0315 | 0.0757 |
| Texas Christian | 1.16528 | 0.2870 | 0.0531 | 0.0222 | 0.0540 | 0.4166 | 0.1560 | 0.0111 | | |
| Vanderbilt | 1.13526 | 0.3102 | 0.1432 | 0.0638 | 0.1921 | 0.0499 | 0.2407 | | | |
| Villanova | 1.47070 | 0.3543 | 0.2487 | 0.1029 | 0.1487 | 0.0918 | 0.0536 | | | |
| Virginia Tech | 1.16548 | 0.0355 | 0.2372 | 0.0986 | 0.0698 | 0.1138 | 0.0697 | 0.0394 | 0.1328 | 0.2033 |
| Washington St. | 1.48555 | 0.2223 | 0.1108 | 0.3825 | 0.2712 | 0.0132 | | | | |

- Output-oriented models with efficiencies scores > 1 are inefficient.
- Input-oriented models, efficiencies scores < 1 are efficient DMUs

Notice the 59% weight given to Team 5 for Arizona

# Inefficient Team Benchmarks

- Using the $\lambda_j$ 's from the previous table, we can find which teams those weights correspond to. Now we have benchmarks for the inefficient teams.
- The $\lambda_j$ of 0.59 corresponds to the relative weight of Virginia (highlighted below)

| Inefficient Teams | | Best-Practices Team Reference Set | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Team | O-O VRS Eff. | Team1 | Team2 | Team3 | Team4 | Team5 | Team6 | Team7 | Team8 | Team9 |
| Arizona | 1.08688 | Tulane | Houston | Young. St. | St. Louis | Virginia | Missouri | Kentucky | Wisconsin | |
| Arizona St. | 1.74559 | Tulane | Boston College | Butler | Virginia | Utah | | | | |
| Charlotte | 1.24896 | Tulane | Sou. Cal | ND | Butler | Sou. Miss | Colorado | SDSU | | |
| Dayton | 1.21850 | Cleve. St. | Cincinnati | Stanford | Virginia | Kentucky | Wisconsin | Syracuse | | |
| East Carolina | 1.26899 | Tulane | Sou. Cal. | Butler | DePaul | Sou. Miss | St. Louis | Virginia | LSU | Wisconsin |
| Illinois | 1.09021 | Sou. Cal | Cleve. St. | Seton Hall | La Salle | Fordham | Cincinnati | Virginia | LSU | Texas |
| Indiana | 1.06573 | SDSU | Stanford | California | Kentucky | UNC | | | | |
| Iowa St. | 1.10090 | ND | Cincinnati | SDSU | Missouri | Kentucky | UNC | | | |
| Maryland | 1.18176 | Tulane | ND | Cincinnati | SDSU | Virginia | LSU | Kentucky | UNC | |
| Miami FL | 1.17818 | Sou. Miss | St. Louis | Missouri St. | Cincinnati | SDSU | Virginia | Syracuse | UNC | Louisville |
| Minnesota | 1.18320 | Tulane | Butler | Virginia | Alabama | Kentucky | | | | |
| North Carolina | 1.12590 | Providence | California | Kentucky | Wisconsin | UNC | Louisville | | | |
| Penn St. | 1.11181 | Tulane | Sou. Cal. | ND | Butler | Seton Hall | Fordham | Rutgers | Cincinnati | Clemson |
| Rhode Island | 1.90618 | Tulane | Wisc. GB | Butler | St. John's | Fordham | Rutgers | Cincinnati | | |
| St. Bonaventure | 1.18929 | Tulane | Creighton | Sou. Miss | Virginia | Kentucky | | | | |
| Tennessee | 1.08522 | Tulane | Sou. Cal. | Wisc. GB | Butler | DePaul | St. Louis | Virginia | Kentucky | Wisconsin |
| Texas Christian | 1.16528 | Tulane | Sou. Cal | Butler | Sou. Miss | St. Louis | Virginia | Wisconsin | | |
| Vanderbilt | 1.13526 | ND | Creighton | St. Louis | Wichita St. | Virginia | Kentucky | | | |
| Villanova | 1.47070 | Butler | St. John's | Cincinnati | LSU | Kentucky | UNC | | | |
| Virginia Tech | 1.16548 | Tulane | Sou. Cal. | Butler | Rutgers | Virginia | LSU | Alabama | Kentucky | Wisconsin |
| Washington St. | 1.48555 | Wyoming | New Mexico | Virginia | Kentucky | Syracuse | | | | |

# Stage2 of O-O VRS DEA Model

- Stage 1 – we found the maximum efficiencies $\theta^*$ which did not include slacks
- Stage 2 – Hold $\theta^*$ constant and obtain the slacks

**Stage 2**

$$\max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+$$

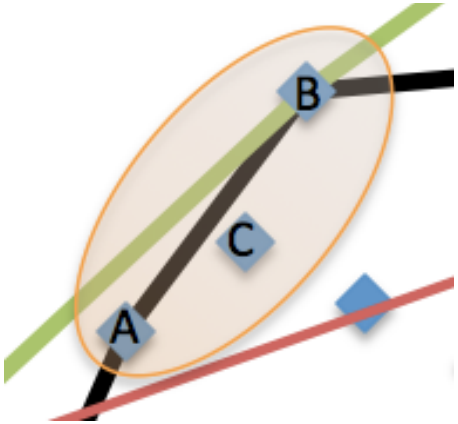
Subject to:

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{i0} \qquad i = 1,..,m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_i^+ \leq \theta^* y_{r0} \qquad r = 1,..,s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad j = 1,..,n$$




**Note:**
$\theta = efficiency\ of\ DMU_0$
$n = \#\ of\ DMUs$
$m = \#\ of\ Inputs$
$s = \#\ of\ Outputs$

# Investigating the slacks

- The non-zero slacks below show the amount of waste of input resources for their corresponding inefficient output (winning percentage)
- In other words, these teams had excess in resources but fell short in output

| Team | Input Slacks | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adj OffEff | Adj DefEff | Adj Tempo | Avg Hgt | Bench Minutes | Off 3PA% | Def 3PA% | Def FT% | Player Exp. | Off FT Rate | Def FT Rate | Off eFG% | Def efg% | Off TO% | Off OR% | Pyth SOS | NCSOS Pyth | Total Staff | Rev/Exp |
| Arizona | 0.64 | 5.11 | 3.67 | - | - | 0.060 | - | - | 0.067 | 0.084 | - | - | 0.001 | 0.006 | 0.011 | - | 0.081 | 1.8 | 1.832 |
| Arizona St. | - | 10.17 | 0.09 | 1.9 | 5.3 | 0.021 | 0.024 | 0.043 | - | 0.032 | 0.024 | 0.039 | 0.025 | 0.059 | - | 0.052 | - | 0.3 | 0.311 |
| Charlotte | - | 1.90 | 3.62 | 0.3 | 1.2 | 0.042 | 0.042 | 0.008 | 0.057 | 0.030 | - | - | 0.013 | 0.013 | - | 0.061 | 0.051 | - | - |
| Dayton | 2.42 | 8.93 | 0.37 | 0.1 | 2.1 | 0.079 | - | - | 0.618 | - | 0.014 | - | 0.047 | 0.009 | 0.016 | - | - | 0.3 | 1.283 |
| East Carolina | - | 6.94 | 2.18 | 0.8 | 3.6 | 0.087 | - | - | 0.354 | - | 0.031 | - | 0.035 | 0.014 | - | 0.006 | - | - | 0.042 |
| Illinois | - | - | 0.16 | 1.0 | 2.4 | 0.021 | 0.021 | - | - | - | 0.022 | - | 0.027 | 0.019 | 0.010 | 0.098 | - | - | 1.664 |
| Indiana | 8.49 | 4.15 | 0.18 | 0.4 | 4.4 | - | - | 0.018 | 0.211 | 0.068 | 0.053 | 0.036 | 0.029 | 0.008 | 0.009 | 0.101 | - | - | 0.797 |
| Iowa St. | - | 0.55 | 2.54 | - | 1.2 | 0.073 | 0.008 | 0.007 | 0.091 | 0.034 | - | 0.014 | 0.017 | 0.016 | - | 0.042 | 0.066 | 0.3 | - |
| Maryland | - | 7.90 | 1.58 | 0.9 | 0.8 | - | - | 0.035 | - | 0.123 | - | - | 0.018 | 0.011 | - | 0.020 | - | - | 0.406 |
| MiamiFL | 1.55 | 5.24 | 0.57 | 0.5 | 6.4 | 0.057 | 0.030 | - | - | - | 0.012 | - | 0.020 | - | - | 0.015 | 0.047 | - | - |
| Minnesota | - | 4.39 | 0.54 | 0.1 | 11.0 | - | 0.032 | 0.047 | - | 0.003 | 0.035 | 0.012 | 0.033 | 0.039 | 0.032 | 0.092 | - | 0.7 | 1.393 |
| North Carolina St. | 0.65 | 4.80 | 1.15 | 0.5 | - | - | 0.025 | 0.028 | 0.461 | - | 0.033 | - | 0.019 | - | 0.016 | 0.013 | 0.101 | 1.2 | 0.889 |
| Penn St. | 3.84 | - | - | 0.4 | 9.1 | 0.060 | 0.108 | 0.039 | - | - | 0.105 | - | 0.037 | - | 0.020 | 0.113 | - | - | 0.903 |
| Rhode Island | 4.41 | 4.49 | 1.05 | 0.7 | 8.3 | 0.024 | - | 0.012 | - | - | - | - | 0.049 | 0.003 | 0.042 | 0.022 | - | - | - |
| St. Bonaventure | 1.08 | 4.53 | - | 0.4 | 2.7 | - | 0.019 | 0.036 | 0.399 | 0.032 | 0.055 | 0.001 | 0.014 | 0.037 | 0.049 | - | 0.060 | 0.7 | - |
| Tennessee | - | 1.51 | 2.32 | 1.2 | 4.4 | 0.016 | - | - | - | 0.053 | 0.007 | - | - | 0.023 | 0.031 | 0.052 | - | - | 0.824 |
| Texas Christian | 1.14 | 11.98 | 6.00 | 0.2 | 0.6 | 0.023 | - | - | 0.443 | 0.018 | 0.055 | - | 0.078 | 0.010 | - | - | 0.001 | 1.6 | - |
| Vanderbilt | 0.74 | - | 1.28 | 0.8 | 3.6 | 0.083 | 0.029 | 0.008 | 0.753 | 0.023 | - | 0.013 | 0.018 | 0.030 | - | 0.072 | 0.081 | - | - |
| Villanova | 4.12 | 4.34 | 2.09 | 1.2 | 6.6 | 0.047 | 0.026 | 0.029 | - | 0.016 | - | - | 0.005 | 0.012 | 0.024 | 0.094 | - | 0.9 | - |
| Virginia Tech | 2.08 | 6.03 | - | 1.3 | 1.8 | - | 0.016 | 0.009 | - | - | 0.018 | - | 0.007 | 0.007 | 0.026 | - | - | - | 0.187 |
| Washington St. | - | 10.64 | - | 0.2 | 4.0 | 0.019 | 0.053 | - | 0.352 | 0.057 | 0.055 | 0.010 | 0.052 | 0.020 | 0.004 | - | 0.024 | 2.2 | 0.111 |

Arizona realized a 93.8 adjusted defensive efficiency (Adj DefEff), but they would could have had 88.7 (-5.11) and still realized the same winning %.

# Actual vs. Target Output

- As we can see, the distribution of actual to target winning % is nicely spaced for our inefficient teams.
- Some programs may be looking for new coaches like Washington state for example.

**How do you obtain the efficient target outputs?**

- Use your benchmark team's input slacks

| Team | Actual Win % | Efficient Target Win% | Difference |
|---|---|---|---|
| Washington St. | 51.4% | 76.3% | 24.9% |
| Arizona St. | 32.3% | 56.3% | 24.1% |
| Rhode Island | 22.6% | 43.0% | 20.5% |
| Villanova | 40.6% | 59.7% | 19.1% |
| Dayton | 60.6% | 73.8% | 13.2% |
| East Carolina | 48.4% | 61.4% | 13.0% |
| St. Bonaventure | 62.5% | 74.3% | 11.8% |
| Minnesota | 60.5% | 71.6% | 11.1% |
| Miami FL | 60.6% | 71.4% | 10.8% |
| Charlotte | 43.3% | 54.1% | 10.8% |
| Maryland | 53.1% | 62.8% | 9.7% |
| Vanderbilt | 69.4% | 78.8% | 9.4% |
| Texas Christian | 54.5% | 63.6% | 9.0% |
| North Carolina St. | 64.9% | 73.0% | 8.2% |
| Virginia Tech | 48.5% | 56.5% | 8.0% |
| Iowa St. | 67.6% | 74.5% | 6.8% |
| Arizona | 65.7% | 71.4% | 5.7% |
| Indiana | 75.0% | 79.9% | 4.9% |
| Illinois | 53.1% | 57.9% | 4.8% |
| Tennessee | 55.9% | 60.6% | 4.8% |
| Penn St. | 37.5% | 41.7% | 4.2% |

# Obtaining input & output targets

- Previously, we depicted the benchmark teams for the inefficient teams based on their weights $\lambda_j$ (Stage 1)

| Team | O-O VRS Eff. | Wyoming | New Mexico | Virginia | Kentucky | Syracuse |
|---|---|---|---|---|---|---|
| Washington St. | 1.48555 | 0.2223 | 0.1108 | 0.3825 | 0.2712 | 0.0132 |

- Then from stage two input slacks were obtained (Stage 2)

| Team | *Input Slacks* | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Adj Off Eff* | *Adj Def Eff* | *Adj Tempo* | *Avg Hgt* | *Bench Minutes* | *Off 3PA%* | *Def 3PA%* | *Def FT%* | *Player Exp.* | *Off FT Rate* | *Def FT Rate* | *Off eFG%* | *Def efg%* | *Off TO%* | *Off OR%* | *Pyth SOS* | *NCSOS Pyth* | *Total Staff* | *Rev/Exp* |
| Washington St. | - | 10.64 | - | 0.2 | 4.0 | 0.019 | 0.053 | - | 0.352 | 0.057 | 0.055 | 0.010 | 0.052 | 0.020 | 0.004 | - | 0.024 | 2.2 | 0.111 |

- Now combining those estimates we can obtain each of the efficiencies for all teams:

$$Wash\ St.(Target) = (0.22 * 0.63) + (0.11 * 0.80) + (0.38 * 0.68) + (0.27 * 0.95) + (0.01 * 0.919)$$
$$= 0.763$$

| Team | *Adj Off Eff* | *Adj Def Eff* | *Adj Tempo* | *Avg Hgt* | *Bench Minutes* | *Off 3PA%* | *Def 3PA%* | *Def FT%* | *Player Exp.* | *Off FT Rate* | *Def FT Rate* | *Off eFG%* | *Def efg%* | *Off TO%* | *Off OR%* | *Pyth SOS* | *NCSOS Pyth* | *Total Staff* | *Rev/Exp* | *Win %* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Washington St. (Actual) | 108.6 | 99.8 | 62.9 | 77.5 | 30.1 | 0.3354 | 0.3734 | 0.6724 | 1.94 | 0.4386 | 0.3651 | 0.5287 | 0.4958 | 0.2046 | 0.3073 | 0.5977 | 0.4745 | 10.00 | 1.39 | 51.4% |
| Washington St. (Target) | 108.6 | 89.2 | 62.9 | 77.3 | 26.1 | 0.3164 | 0.3200 | 0.6724 | 1.59 | 0.3812 | 0.3104 | 0.5183 | 0.4438 | 0.1843 | 0.3031 | 0.5977 | 0.4508 | 7.80 | 1.28 | 76.3% |
| Efficient Benchmarks | | | | | | | | | | | | | | | | | | | | |
| Wyoming | 99.2 | 92.5 | 61.0 | 76.0 | 25.6 | 0.3850 | 0.3274 | 0.7083 | 2.33 | 0.3837 | 0.3702 | 0.5098 | 0.4674 | 0.1895 | 0.2405 | 0.4978 | 0.3135 | 8.00 | 0.93 | 63.6% |
| New Mexico | 111.0 | 89.7 | 66.3 | 77.1 | 34.7 | 0.3708 | 0.3598 | 0.6787 | 1.67 | 0.3876 | 0.3149 | 0.5277 | 0.4440 | 0.2010 | 0.3439 | 0.5491 | 0.4498 | 9.50 | 1.20 | 80.0% |
| Virginia | 102.9 | 87.7 | 60.6 | 76.9 | 26.7 | 0.2976 | 0.3241 | 0.6343 | 1.71 | 0.3541 | 0.3115 | 0.5067 | 0.4471 | 0.1875 | 0.2750 | 0.5892 | 0.3945 | 7.00 | 1.31 | 68.8% |
| Kentucky | 122.9 | 88.2 | 66.2 | 78.8 | 21.6 | 0.2647 | 0.2896 | 0.6938 | 0.77 | 0.4173 | 0.2581 | 0.5376 | 0.4197 | 0.1698 | 0.3746 | 0.7061 | 0.6361 | 8.00 | 1.50 | 95.0% |
| Syracuse | 118.1 | 90.3 | 65.2 | 78.6 | 33.9 | 0.3098 | 0.3619 | 0.6761 | 1.68 | 0.3288 | 0.3096 | 0.5206 | 0.4421 | 0.1595 | 0.3615 | 0.7068 | 0.5925 | 9.50 | 2.52 | 91.9% |

# Benefits of this analysis

- Provides elements about each team that a coach or athletics department may not be aware of via optimization techniques
- Washington State for example:
  - improve their adjusted defensive efficiency (10.64)
  - reducing their bench minutes (4.05)
  - consider reducing their total staff from 10 to 8 (2.2)

| USA Today Coaches Poll | | | |
|---|---|---|---|
| RK | TEAM | RECORD | PTS |
| 1 | Indiana (21) | 0-0 | 761 |
| 2 | Louisville (5) | 0-0 | 738 |
| 3 | Kentucky (5) | 0-0 | 718 |
| 4 | Ohio State | 0-0 | 617 |
| 5 | Michigan | 0-0 | 605 |
| 6 | North Carolina State | 0-0 | 581 |

**Interesting observations**

- 2 of our 21 2011-12 inefficient teams had a respectful performance in the NCAA tournament with Indiana and North Carolina State both making it to the Sweet 16

Indiana's target winning percentage last year was 80%, a five percent increase from what was realized may have made turned a Sweet 16 into a National Championship

Had NC State played slightly weaker competition, they may have won more which would have made up some ground at achieving their target winning percentage of 73%, an 8.2% difference from what was realized

# Current Research (theoretical & applied)

Recall the…

**Disadvantages**

- the number of efficient DMUs on the frontier tends to increase with the number of inputs and output variables
- results can be sensitive to the selection of inputs and outputs
- you cannot test for the best specification

The only guidelines regarding which resources impact production is that the sum of inputs and outputs used should be less than or equal to one-third the number of DMUs used in the investigation. Cooper, et. al suggests using $n \geq \max\{m \cdot s, 3(m+s)\}$

**Current research:**

Since efficiencies are "relative efficiencies", the 127 teams are probably still not exactly homogenous, so peer benchmarks might not be reasonable

- Efficiency by conference or smaller clusters of DMUs
- Improved methods for DEA variable selection