Keys to Success in a Run-and-Gun Basketball System

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Abstract:

Since 1991, Coach David Arseneault of Grinnell College has used a unique style of run-and-gun basketball that he calls "The System." In a 1997 book, he outlines what he considers the keys to winning basketball games within "The System." These keys are defined as meeting thresholds in various offensive and defensive game statistics. Using data from 9 seasons, we use classical statistical methods to challenge Coach Arseneault's keys and, where possible, refine them.

Introduction:

Coaching men's basketball at Division III Grinnell College has not been a way station toward the Hall-of-Fame in Springfield, Massachusetts. Of the 9 coaches who have held that post since World War II, none had career winning records until the current coach David Arseneault, who came on the scene in 1989. David's first two years stretched a streak of 26 straight losing seasons into 28, before his 11-11 season got Grinnellians used to the notion that they might permit themselves to sniff success from time to time in the win-loss column. Since then, David has experienced just 7 losing seasons the past 20, has achieved a career coaching record of 275 wins versus 230 losses, has guided his team to 5 Midwest Conference championships, and has been the conference's "coach of the year" 5 times.

While by Grinnell's standards—which never put preeminence on wins and losses—this record is excellent, it's still not the stuff of Springfield, Mass, nor would it explain the list below, a list that Grant Wahl of Sports Illustrated put together in a 2003 article to answer a fan's question: Who are the most innovative men's college basketball coaches?

- Roy Williams
- Bill Carmody
- Rick Pitino
- Mike Krzyzewski
- Bob Knight
- Jim Boeheim
- Lute Olsen
- David Arseneault
- Tubby Smith
- Billy Donovan

Why would Coach A be included on such a list? Consider this quote from Wahl's article:

“You've gotta see it to believe it. Arseneault's D-3 Pioneers make those legendary Loyola Marymount teams look like they were running the four-corners offense. Using an attack that emphasizes shooting the ball every 12 seconds, giving up 2-pointers so you can get 3s, and going up to 17 players deep, Grinnell has led all NCAA levels in scoring and 3-point shooting for the past 10 seasons. (This year's Pioneers, we might add, are 5-0 and averaging 133.2 points and 21.6 treys per game.)”

Using a style of play that eventually became known as “The System” David transformed a moribund program into one that is fun for the players—where all members of the team have a role—and fun for the fans. Terry Glasgow, coach of conference rival Monmouth College, has described playing against Grinnell as like opening up a shoe box with 5 mice in it.

Coach Areseneault said recently that he worries when a player dwells too much on winning; he wants them to enjoy playing with abandon and piling up weird statistics. Consistently the team leads the NCAA in scoring average per game, three point shooting, and steals. Grinnell has led the country in scoring 16 of the past 18 years, with a high-water mark of 126 points per game in 2002-03. This past year they led in all three categories averaging 103 points per game scoring, on nearly 18 threes, and 15 steals.

In his 1997 book *The Running Game*, Coach Arseneault states a “formula for success” in terms of 5 statistical goals for each game:

- Make at least 150 trips up and down the court for the game;
- Grinnell takes at least 94 shots in the game;
- At least half of these shots are three-point attempts;
- Grinnell rebounds at least 33% of its missed shots;
- Grinnell forces the opponent into at least 32 turnovers.

David derived these keys based upon another student project he had directed a couple of years into the system. By “trips,” Coach Arseneault actually recorded from game film how many times the opposing center traveled between the two hash marks of the court. This was the only statistic mentioned in his keys that could not be recorded or derived from the stat sheets and it was tedious to record. (Stat sheets are statistical summaries prepared by the sports information director and his crew during the game.) Moreover, he found it useful to compare his keys at the half-time of a game, simply by viewing the half-time stat sheets and this made the trips key impractical. Thus he substituted for his first key to success one based upon shot differential, namely:

- Grinnell should attempt at least 25 more shots than its opponent.

The data and basic analysis:

This JSM talk comes from a student project that Ben and Eric did for a class in the spring of 2006 that was taught by Tom. Ben and Eric are each now well into the pursuit of PhDs in economics; at Grinnell both were top students and excellent athletes: Ben in golf and Eric, tennis. Both were enthusiastic fans of our men’s basketball program, which led them to this project.

They collected data on all 147 Midwest Conference games for a 9 year period ending in 2005-06. Using the stat sheets they created a data set with 147 cases and over 30 variables. We call this data set *Hoops*. Subsequently, Tom selected a second data set, which we call *LateYears*, comprising all 88 conference games from the 2006-07 season through the 2010-11 season. We use *Hoops* to build models and *LateYears* to validate them.

Table 1 summarizes four possible approaches to modeling the data, all of which we considered and tried to some extent. We ultimately preferred the fourth of these—ordinary least squares regression, with the response variable being Point Differential and using for predictors the variables from which the keys to success are defined. The option of making Y binary and using logistic regression (the top, left-hand option) gave similar results to what our approach found, but there is some loss in precision with using a binary response, whereas Point Differential affords a more nuanced view of the game's result. Moreover, Point Differential better captures the spirit with which Grinnell tries to approach athletic competition: a 2 point loss really is a better outcome—competitive game, excitement for fans and players—than a 20 point loss. The disadvantage of using predictors that are dummies based upon Coach A's thresholds is that it gives little flexibility to ascertain if the problem is with the thresholds or with the variable itself. We were focusing in our analysis on which variables seem to predict success in the game's outcome.

Y = win-loss (binary) X = dummies based on keys	Y = win-loss (binary) X = variables keys are based upon
Y = Point Differential X = dummies base on keys	Y = Point Differential X = variables keys are based upon

TABLE 1: *Possible approaches to modeling game's outcome (Y) based upon a set of predictors (X).*

Over time, many of 30-plus variables entered our analyses, but for this paper we will consider only the following subset of variables, from which we extracted what we consider to be a useful way to model the data:

- Response: PtDiff = Grinnell Score – Opponent Score
- Predictors:
  - TRIPS = the number of times the opposing center travels between hash marks
  - GrAtt = number of shots Grinnell Attempts
  - ShotDiff = GrAtt – OppAtt = Grinnell attempt minus opponent attempts
  - ThreePer = Proportion of Grinnell attempts beyond "the arc"
  - ORPer = Proportion of its missed FGs that Grinnell rebounds
  - OppTO = number of turnovers opponent commits
  - TODiff = OppTO – GrTO
  - GrAss = number of assists by Grinnell

Figure 1 shows Point Differential against Grinnell's score, to give a sense of the range and variability of scores and to convey that Grinnell wins about half its games; the win-loss record was 77-70 during these 9 years.

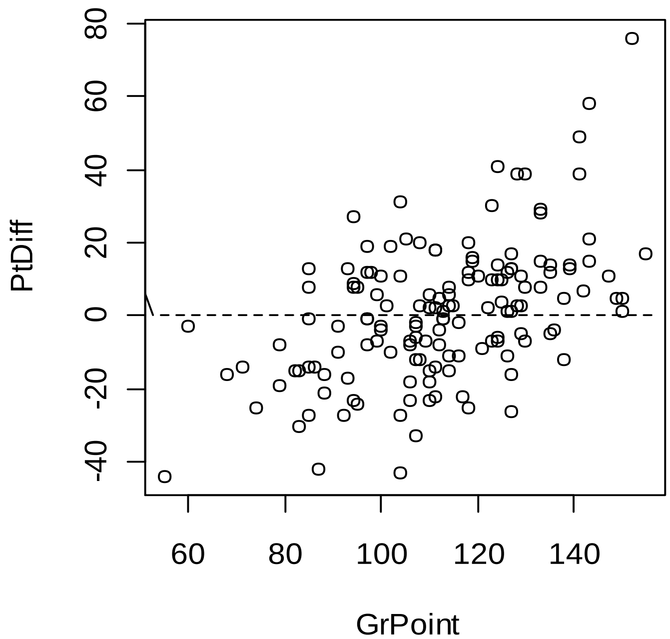

Figure 1: *Scatterplot of point differential (PtDiff) against Grinnell's Score (GrPoint). Points above the horizontal line represent wins, points below losses. The win-loss record for the 147 games was 77-70. Note the high number of points typically scored by Grinnell.*

The goal of our analysis:
The goal that Ben and Eric pursued was to see if the Statistical Goals established by Coach A translated into a good regression model and if they could find some reasonable improvement over this model.

First we restate the "keys to success" in terms of the variables:

- ShotDiff ≥ 25
- GrAtt ≥ 94
- ThreePer ≥ .50
- ORPer ≥ .33
- OppTO ≥ 32

It is instructive to view in a simple way the relationship each of these keys has to wins and losses, which we summarize in Table 2.

TRIPS[1]				SHOT DIFF			
	L	W	Win%		L	W	Win%
FALSE	5	5	50%	FALSE	34	45	57%
TRUE	65	72	53%	TRUE	36	32	47%
GRINNELL ATTEMPTS				THREE PER			
	L	W	Win%		L	W	Win%
FALSE	42	45	52%	FALSE	5	10	67%
TRUE	28	32	53%	TRUE	65	67	51%
OR PER				OPPONENT TURNOVERS			
	L	W	Win%		L	W	Win%
FALSE	28	19	40%	FALSE	60	56	48%
TRUE	42	58	58%	TRUE	10	21	68%

TABLE 2: *Winning percentage versus whether Grinnell exceeds the thresholds established by their coach. Note that TRIPS, SHOT DIFF, GRINNELL ATTEMPTS, and THREE PER do not appear to correlate positively with winning, whereas Offensive Rebounding (OR PER) and OPPONENT TURNOVERS do.*

Note that Trips, Shot Attempts, and three-point shooting fraction—while overtly the most obvious features that distinguish the system from traditional ways of playing the game—seem to correlate weakly or inversely to what we might expect. As noted above, Coach Arseneault substituted Shot Differential for Trips, because Trips was hard to count and because he wanted a statistic he could evaluate at the half time of a game. Shot Differential is negatively correlated with win-loss.

Regression modeling:

We now discuss a series of regression models.

We first look at what we call David's Model (and label it David1), because it is a regression model based upon the variables mentioned in Coach Arseneault's keys. (See Table 3.)

Predictor	Coef	P-value
ShotDiff	-.30	.083
ORPer	55	.009
GrAtt	.15	.314
ThreePer	-24	.132
OppTO	.84	.001
R^2 = 12.9%	S=17.8	

TABLE 3: *David's model (David1): based upon variables that define Coach A's keys to success.*

We note that there is a decided lack of power in the model (the R^2 of 12.9%). Note the residual standard error of 17.8, which we can, it turns out, improve upon substantially.

Ben and Eric considered several alternative models, and Table 4 summarizes one that combines some features of David's model with some new variables. (We label this and a later related model with the Student prefix.)

Predictor	Coef	P-value
ShotDiff	-.68	0.000
ORPer	97	0.000
GrAssists	.78	0.000
TODiff	2.0	0.000
R^2 = 51.6%	S=13.2	

TABLE 4: *Students' model (Student1): Retains ShotDiff and ORPer from David's, but removes others and replaces them with Grinnell's assists and turnover differential.*

Note the improvement in R^2 and S; it turns out that these values are typical of a series of models we built and it was hard to improve much beyond these values.

Note also that in the Students' Model all 4 variables are statistically significant contributors.

Note finally the anomalous negative coefficient on Shot Differential: controlling for other things, each extra shot Grinnell takes over its opponent corresponds to a two-thirds of a point drop in point differential. We find it difficult to explain this negative sign, although it confirms the simple negative correlation we saw earlier between Shot Differential and Point Differential, unconditioned on other variables (Table 2).

The interview:
It was about this point in the analysis that Tom decided to interview Coach Arseneault[2]. We thought that this would give us a practical perspective on our analysis that could give us a next step.

Here are some points we learned in that interview[3]:

- The original keys were "data based." That is, Coach Arseneault based them on a student project done in the early 1990s that pointed out the statistical patterns that led to the keys.
- Substituting ShotDiff for Trips is for convenience: ShotDiff can be found on stat sheets; Trips requires close observation of game film.
- Keys are based upon "coachable" statistics:
  - Our full-court defense is geared towards creating turnovers and, thus, elevating the game's pace.
  - Offensive Rebounding in "The System" is different: longer rebounds and trickier angles. Grinnell recruits a non-traditional player who is typically not a conventionally good rebounder, but the skills to rebound in "The System" can be taught and many hours of practice time are devoted to this skill.
- Half-time assessment is useful. The coach peruses the half-time stat sheets to assess the keys and consider strategy for the second half.
- Keys and thresholds are more practical than regression models. That is, Coach Arseneault thinks in terms of thresholds, not regression models. Also the latter would be impractical for quick, half-time assessment.
- The Assist is a suspect statistic. Coach Arseneault does not trust this statistic for a variety of reasons. For this reason, we excluded it from subsequent models.

Predictor	Coef	P-value
ShotDiff	-.72	0.000
ORPer	102	0.000
TODiff	2.1	0.000
R^2 = 46.0%	S=13.9	

TABLE 5: *The second students' model (Student 2): Note that R^2 is nearly as good (46% versus 52%) as in Student1, and S has only increased from 13 to 13.9.*

Our next step then was to fit a second model (Student 2, Table 5) that left out the assists variable. Student2 is nearly as effective as Student1 in predicting point differential: R^2 is still nearly 50% and S has only slipped from 13.2 to 13.9.

We then created a second model called David2 that eliminated the non-significant predictors GRAtt and ThreePer from David1. (See Table 6.) In creating this model, we made sure that neither predictor alone would add significantly to a model that already included the predictors ShotDiff, ORPer, and OppTO and neither did. We chose to retain ShotDiff in David2, at first, because it was nearly significant in David1, but ultimately also because, even though it was non-significant in David2, its inclusion made the subsequent comparisons cleaner.

Predictor	Coef	P-value
ShotDiff	-.21	0.148
ORPer	59	0.005
OppTO	.87	0.001
R^2 = 11.1%	S=17.8	

TABLE 6: *The second David model (David2): We removed superfluous variables from David1.*

Model diagnostics:

We have before us now the following 4 models:

David 1 using ShotDiff, ORPer, GrAtt, ThreePer, OppTO
David 2 using ShotDiff, ORPer, OppTO
Student1 using ShotDiff, ORPer, GrAss, TODiff
Student2 using ShotDiff, ORPer, TODiff

For all of our models, we used standard regression diagnostics to assess the usual model conditions for linear regression. All models met the conditions for linearity, constant variance, and normally distribution errors. We computed autocorrelation functions for the residuals of the four models, and compared autocorrelations of various lags to see if any were outside the conventional guideline of $\pm 2/\sqrt{n} = \pm 1.65$. Lag 1 correlations for the four models were: .222 for David1, .266 for David2, .174 for Student1, and .164 for Student2. Based upon this criterion, there were suggestions of some serial correlation at lag-1.

Durbin-Watson tests also gave results significant at the .05 level. Even though the level of lag-1 serial correlation seemed slight, we took the precaution to explore the issue further. Recall that when one uses ordinary least squares in the presence of lag-1 serial correlation, the coefficient estimates are still unbiased, but the residual standard error and the estimates of coefficient standard deviations may underestimate the truth. Ramsey and Schafer [pages 445-448] recommend the method of "regression with filtered variables" to better estimate these standard errors, while giving approximately the same values of the coefficient estimates.

We used their recommendation to re-fit each of our four models. In each case, the standard errors for coefficients were only slightly larger and not enough to affect conclusions reached above. Table 7 gives one instance, for illustrative purposes.

Predictor	**Coef**	**P-value**
ShotDiff	-.30	.072
ORPer	59	.004
GrAtt	.04	.790
ThreePer	-12	.421
OppTO	1.00	.000
R^2 = 15.6%	S=17.2	

TABLE 7: *A refitted David1 model, using regression on filtered variables to account for possible lag-1 serial correlation. Note that the coefficient magnitudes are similar to the original David1 and that statistical significance has not been substantively affected.*

These results convinced us that serial correlation was not adversely affecting the models we had fit with ordinary least squares. We proceeded from there to compare our models based upon their practicality and their predictive success on the *LateYears* validation sample. We then converted the Student2 model to a new set of "keys to success" and compared these keys to the old keys.

Model comparisons:

David1 suffers from containing extraneous predictors. Student1 suffers from containing GrAss, which is—for the coach—an untrustworthy statistic. Therefore, the salient comparison is between David2 and Student2. The only difference between the two is the use of turnovers: David2 uses *opponent's* turnovers while Student2 uses turnover *differential*. This difference makes Student2 a substantially better model, at least as measured by R^2 and S. Figure 2 illustrates the superiority of TODiff to OppTO using added-variable plots.

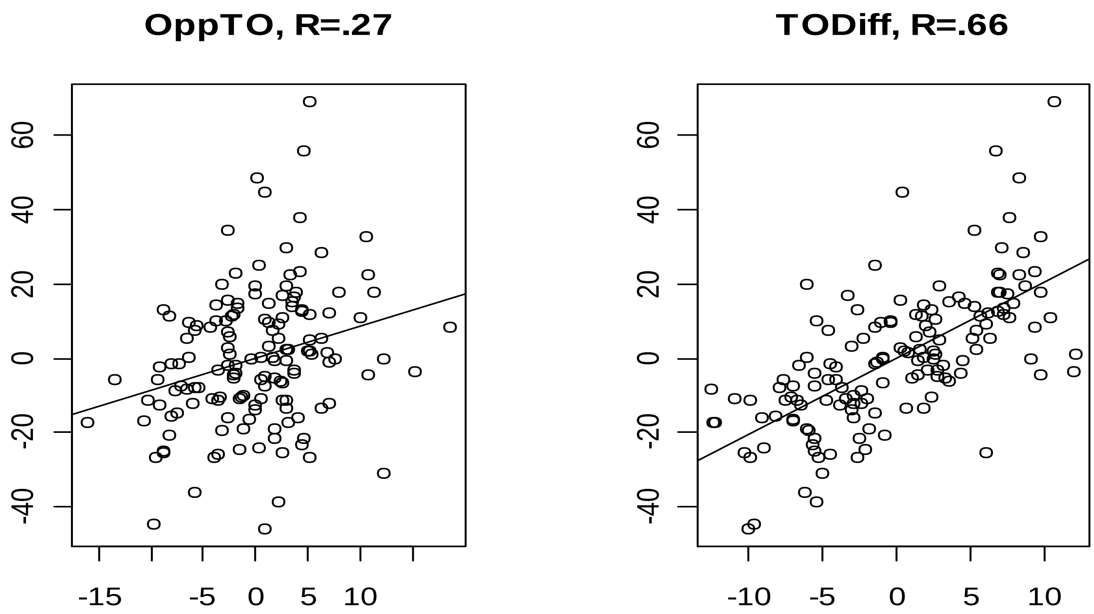

Figure 2: *Added-variable plots of OppTO after ShotDiff and ORPer (left) and of TODiff after ShotDiff and ORPer (right). Note that TODiff does the much better job of explaining the remaining variation after fitting the first two predictors.*

Validation of the models using *LateYears* and some new "keys to success":
We next tested each of our 4 models—David1, David2, Student1, Student2—on the validation sample, *LateYears*. For each model, we predicted point differential for each of the 88 games in *LateYears* and translated this to a win or a loss. We then compared those predictions to actual wins and losses and obtained the results in Table 8.

We see that both of the "student" models do a better job of predicting than the models we derived from Coach A's keys to success.

Since Coach Arseneault needs the more practical "keys to success," rather than regression models, our next step was to translate the Student2 regression model into an alternative set of keys to success.

Model	Predictions	C%
David1	60/88	68%
David2	63/88	72%
Student1	71/88	81%
Student2	72/88	82%

TABLE 8: *Correct predictions occur at the rate given by C%. Notice that the two David models predict at a rate about 10 to 14 percentage points below the student models.*

Thresholds suggested to us that a regression trees approach might be fruitful, so we used R's tree function to perform the following sequence of calculations on the *Hoops* dataset:

1. Using `tree(PtDiff ~ ShotDiff + ORPer + TODiff)` we found the primary split was on TODiff with a threshold of 11.5. The variable of secondary importance for splitting the data was ORPer.
2. We then created two subsets of the *Hoops* dataset: *HoopsLow*, those cases with TODiff < 11.5, and *HoopsHigh*, those cases with TODiff > 11.5.
3. For each of the subsets from (2) we used the R calculation `tree(PtDiff ~ ORPer)`. For *HoopsLow* the threshold value for ORPer was .411; for *HoopsHigh* the threshold was .355.

We ignored ShotDiff for our new keys, because it correlates negatively with Point Differential.

At this point we need to define new keys. Keys are not conditional, but the thresholds arising from the regression trees are. Because of this fact, the step from the two thresholds of .411 and .355 to a single threshold was ad hoc. We considered several possibilities, such as using .411, using .355, or using a mid-value between them. From the *Hoops* dataset, we found that Grinnell attains the .33 threshold or better about 68% of the games, the .355 threshold about 57% of the games, and the .411 threshold about 30% of the games. All three thresholds are eminently attainable. We suspect this is in large part a tribute to Grinnell's attentiveness to offensive rebounding.

In the end, we decided to make the comparison between the change in how turnovers are treated in our models, so we preserved the old threshold for offensive rebounding and posed the new keys given in Table 9.

Old Keys:	New Keys:
• OppTO ≥ 32	• TODiff ≥ 12
• ORPer ≥ .33	• ORPer ≥ .33

TABLE 9: *Keys to Success: Old Keys on the left; New Keys on the right. We retain the .33 threshold for ORPer. Note: The "greater than 11.5" is more naturally stated as "greater than or equal to 12."*

Validation of Keys

We next used our validation sample *LateYears* to see if win-loss success correlated well with whether the team met the statistical goals in the keys to success. Table 10 shows the results.

Goals	Loss	Win	Win%	Goals	Loss	Win	Win%
0	16	18	53%	0	12	7	37%
1	15	34	69%	1	13	29	69%
2	0	5	100%	2	6	21	78%
Old Keys				**New Keys**			

TABLE 10: *Does the number of statistical goals met (Goals) correlate with winning percentage? We assert that the New Keys do a better job of predicting the outcome of a game.*

We note that with the old keys, there is less of a difference between meeting 0 goals and meeting 1 goal—53% to 69% versus 37% to 69%. This is evidence that New Keys do a better job of discriminating wins from losses than Old Keys. And while the difference in going from meeting 1 goal to meeting 2 goals seems to favor the Old Keys (69% to 100% versus 69% to 78%), the difference for New Keys—69% to 78% — is still good, and the advantage that Old Keys seems to have is greatly mitigated by the infrequency with which the team attains 2 goals. Grinnell attained 2 goals only 5 of the 88 games (5.7% of the games) with Old Keys, but attained 2 goals 27 of 88 games (30.7%) with New Keys. If attaining 2 goals is going to be a useful yardstick, the team should have a reasonable chance of attaining it.

Summary:
Using ordinary regression analysis, we assessed Coach Arseneault's keys to success and proposed new ones. We found that the variables that measure the number of shots attempted and the percentage of attempted shots beyond the arc are not useful for predicting the team's success. Also, we found shot differential to be counter-intuitively negatively correlated to success.

The main improvement we made to Coach Arseneault's keys to success was in replacing opponent turnovers with turnover differential. This change should fit nicely in The System's style of play since its full court defensive pressure strives to create opponent turnovers and its desire to shoot quickly allows little time for committing turnovers of its own. The new key based upon turnover differential might also suggest that, even though Grinnell may give itself limited opportunity to commit turnovers on the offensive end, it will still improve its chances of success by "taking care of the basketball" with the little time it does take to shoot.

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[1] Trips here is really a surrogate for Trips derived from the stat sheets, not the actual Trips that Coach Arseneault counted from game film.

[2] Actually, Tom Moore interviewed both Coach David M. Arseneault and Assistant Coach David N. Arseneault on June 23, 2011.

[3] Many of these points are explained, as well, in *The Running Game*.