Performance Densities in Elite Sports

Backgrounds
Practice

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“Sport has the power to change the world. It has the power to unite people in a way that little else does. Sport can awaken hope where there was previously only despair.”

- Nelson Mandela
Three parts:

1. Backgrounds
2. Practice
3. Future and research problems
Progress of the Men’s World Records Speed Skating

- Tight fit clothing
- Indoor rinks
- Artificial ice rinks
- Klapskate
Development Skating Times

- Times decrease
- Differences become smaller
• https://youtu.be/6gi1BEl0ceY
PYEONGCHANG, South Korea (Reuters) - Martin Fourcade won the men’s 15km mass start biathlon by mere millimeters but the history books will show that the gold medal made him France’s greatest Olympian, regardless of the margin of victory.
Competition Crisis

Sometimes the differences are not measurable anymore: they are within the error margins of the measuring systems.

Was the fifth gold medal of Michael Phelps in China indeed gold? 0.01 seconds!!

Phelps

Cavic
The performance differences at the top between elite athletes are nowadays very small.

BUT............
is the finish line indeed exactly perpendicular to the riding direction?

FAIRNESS point!! 0.00025s
15 km biathlon
Norway 2007

Within the error margins of the measuring systems.

Unfair winner
Grand National 2012 Steeple Chase

Is the finish line correct!!!
official time system: all three \textit{ex aequo}

photo winner: top
Tour de France 2017, 7th stage
Marcel Kittel declared winner
Edvar Boasson Hagen second
UNFAIR?

https://www.youtube.com/watch?v=44F1J3wMMSk
Two thousandths of a second was the difference between second and third place in Sunday’s 5,000-speed skating final at the Winter Olympics 2018. Canada’s Ted-Jan Bloemen secured the silver medal in Pyeongchang, with a time of 6:11.616.
What to do when a finish photo is not available or is not accurate?

Examples:
- Speed skaters or skiers are in different pairs;
- Finish line is not ‘perpendicular’.

Then we only have the TIME measuring system:
but NOT ALWAYS ACCURATE!!!!
An iconic picture

Time system winner: Shani Davis.

Both athletes in the same ‘pair’!!!

https://www.youtube.com/watch?v=WYdcYW8R-ic
If Simon Kuipers and Shani Davis would have skated in different pairs, then nobody would have ‘seen’ that Kuipers was the actual winner.
The Dutch speed skater, Koen Verweij, lost the 2014 Olympic gold medal with

0.003 (!!!) of a second.
Koen Verwey (left) loses GOLD with 0.003.
Interesting paper in
Journal of Sports Science
Steve Haake, David James, and Leon Foster
Sheffield Hallam University

Mean of top 25 performances for 8 men’s and 5 women’s field events from 1948 through 2012.

Conclusion of this paper:

Performance leveling will only change if an intervention (new technology, rule change, new athlete population) takes place.
The Gould Effect

1986: Stephan Jay Gould, evolutionary biologist

Gould:
When complex systems improve over time and when the best performers play by the same rules during this process, then the performances of the participants equilibrate and the variation of the top performers decreases.

There is a constant improvement of the level of competition due to just practicing, called the maturation process.

More and more the limits of what is humanly possible are reached.
This leads to a certain leveling of performances at the top, and extreme events, where some players are much better than their rivals, become rare.

The differences in performances between elite athletes, and between top teams become smaller and smaller over time, and extreme events become more and more rare.
Gould discovered ‘his’ effect for American Baseball


Gould’s paper discusses the disappearance of 0.400 baseball hitters, i.e., of baseball players that are able to hit an average of over 40% of the balls during one season.

40% is very high:

*only the super stars* could reach that level.

General feeling of that time (newspapers/TV):

down.
The so-called fast converging trend:
For seven elite 5000m speed skaters:
in Febr. 2008 the difference was more than 1,5 secs.
Two years later: only about 0,5 secs!!
Kramer is in 2015 not anymore an ‘extreme event’.
Stephan Jay Gould:

The true reason is:

the sport becomes more and more matured.

Athletes become **better and better**, not worse!
teams become **better and better**, not worse!

There is a wall, a limit to the improvements.

How to measure / quantify the Gould effect?
Differences with best five skaters, AV5-values
Corrected AV5-values

Question: Is this last correction the ‘Gould maturation’?
(The three lines refer only to tendencies.)
What are consequences?

What are relationships with FAIRNESS?

1. The wrong athlete is declared the winner;
2. More and more ex aequo situations;
3. Less extreme situations (Bolt, Froome (?), Kramer, Phelp, et cetera).

….when a rare extraordinary situation occurs, then very often the first reaction is:

\textbf{doping} !!

\textbf{Gould}: a complex system \textbf{collapses} when the rules of the ‘game’ are not adapted.

So, the rules of the game need to be changed!!!
Keer goud na 2.713 meter

In de olympische historie hebben twee skiesters de afdaling Tina Maze en Dominique Gisin.

0,02, toen 0,13 en daarna 0,38. Maar in het laatste kwart van de race kon ze de voorsprong niet vasthouden, mogelijk omdat de ijsniveau iets zachter was geworden door de stijgende temperatuur (80 graden). Toen ze de finish passeerde stond de kloks op 0,00.


2x gold!!
Rio 2016, 100m butterfly:
3x silver with Phelps
or …4x GOLD

World Ch. Gymnastics 2015
Difficult to measure outcomes \((Who\ are\ the\ winners?)\): Realized performances

Difficult to compare tournament and match results:
Past performances

Difficult to select \((e.g.,\ for\ Olympic\ Games)\)
Expected performances are based on past performances
Olympic Selection and Fairness

Dutch Olympic Speed Skating Selection

KNSB / NOC*NSF

KNSB
ORTEC/Sports
University of Groningen

Arie Koops
Bertus Talsma
Gerard Sierksma
Why difficult?

The comparison of performances is based on past performances reached usually under different conditions and with high performance densities in case of Dutch speed skating.

Moreover, selection decision need to be made ‘NOW’ … the actual performances are ‘LATER’.

The calculated (...) expectations are used TWICE
1. (decision) for making decisions now;
2. (benchmarking) for analyzing performances later.
Important assumptions / starting points:

1. Support.
   Selection procedure needs a broad support, both from athletes, coaches and ‘deciders’ (KNSB and NOC*NSF);

2. Controllable/repeatable/objective.
   The selection procedure has to be ‘objective’, in the sense that when repeated the same results are obtained;

3. The procedure must be legally watertight.
Objective:

As high as possible in the 2018 Winter Olympics Medal Table (goal: Top 5).

This table is a list of countries (actually of National Olympic Committees).

The ranking is lexicographical (we use the expression prio:gold/silver/bronze).
What are the restrictions?

1. There are only 8 athletes per sex + 2 if the Team Pursuit team qualifies;
2. There is a total of 16 individual starting positions per sex;
3. Two of these concern the 2 Mass Start positions;
4. Three positions must be selected from the above (8 + 2 =) 10 for the Team Pursuit.
Overview starting positions
situation Winter Games 2018

500m(m/w), 1000m(m/w), 1500m(m/w), 3k(w), 5k (m)  3 start positions
5k(w) en 10k(m)  2 start positions
Mass Start  2 start positions
Total  16 individual start positions per sex
Total  10 skaters per sex

Team Pursuit  3 skaters (+ 1 reserve)

(These 3 Team Pursuit skaters are to be selected FROM the 10 selected skaters on the individual distances!!!!)
Because of the ‘max 10’ – restriction

**it may be well possible** that a 5000m-specialist, with a low prob of winning a medal, starts on the 1500m,

and that

Kjelt Nuis with a difference of 1-thousands of a second on the 1500m of the OKT (so he is a potential Olympic winner) **has to stay home**.

Fair according to the rules, but it feels ....
Data, and ‘winning’ probabilities

- 5 World Cups       2016-2017       weight 1
- World Ch Single Dists 2017       weight 2
- 4 World Cups       2017-2018       weight 2

The results of the A and B groups are taken together. Match results are transformed to AV5-times:

differences with the average top-5 per distance race.

AV5-values are used as input for simulating 5000 races per distance. The simulation results in probabilities for each skater being 1, 2, or 3.
Math Approach

Maximize (the objective!!)
Total prob. of winning a medal *prior* gold-silver-bronze.
Schematic model

max 10 skaters

Skaters

S1
S2
S3
Si

Prob. of ...

Distances

500m (3)
1000m (3)
1500m (3)
5000m (3)
10000m (2)
Mass Start (2)
Model
variables and parameters

Parameters:

\( C_{ij} = \text{prob. of winning (prio:g/s/b) of skater i on dist. j.} \)

Decision variables:

\( x_{ij} = \begin{cases} 1 & \text{skater i starts on dist. j;} \\ 0 & \text{otherwise.} \end{cases} \)

\( z_i = \begin{cases} 1 & \text{skater i is selected;} \\ 0 & \text{otherwise.} \end{cases} \)
Integer linear optimization model

\[ \text{Max } \sum \sum c_{ij} x_{ij} \]

\[ \sum x_{i,500m} \leq 3 \quad x_{ij} \in \{0,1\} \]

\[ \sum x_{i,1000m} \leq 3 \quad x_{ij} \leq z_i \text{ (\geq integer)} \quad \forall i, j \]

\[ \sum x_{i,1500m} \leq 3 \quad \sum z_i \leq 10 \]

\[ \sum x_{i,5000m} \leq 3 \quad \sum x_{ij} \geq z_i \quad \forall i \]

\[ \sum x_{i,10000m} \leq 2 \]

Note the logical restriction(s).
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<tr>
<td></td>
<td>Verheijen</td>
<td>Van de Kieft</td>
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</table>
But .....
The KNSB wants a trial:

**Olympic Qualification Tournament (OKT)**

The starting tickets have to be distributed via a *competition*,
and not via a *calculation*. 
The final selection methodology:

Performance- or Probabilities matrix both for men and women with the winning probabilities.

Selection ranking (SeVo): lists of the 16 individual starting tickets, ranked from highest to lowest probabilities from the Performance matrices.

OKT: trial tournament in December prior to the Games. Based on the OKT-results the SeVo’s are filled out, taking into account the various restrictions (such as the quotation bound of 10 athletes per sex).
Table 4.4: Performance matrix, $PM^3$ ($PM^6$), December 2010, Dutch female skaters (in %)

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### Performance matrix \( PM^3 \), December 2010, Dutch male skaters (in %)

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..... and then we have to wait and see whether or not the high (...) expectations come true.
Kramers wrong lane change Vancouver 2010.
Expectation ≠ Realization

Giro d’Italia 2016
Stephan Kruiswijk

... only one stage to go!
## Sochi 2014

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Some Research Questions

How to quantify the Gould Hypothesis for both women and men?
Define appropriate *performance indicators*.
Quantify the concept of *extreme event*. What is the trend of the extreme events?
When can we expect, say, three 500m speed skaters within the error margins of the measuring systems for, say, the first place?
Apply sensitivity analysis on the parameters used.
Et cetera.
We use, among others, in our simulations: *probabilities that a Dutch skater wins Olympic gold.*
What is this probability when it is purely based on:

a. different skaters won, say, five world cups, or
b. these five world cups are won by one skater?

Design a ‘better’ selection procedure.
The Secret of Dutch Speedskating - WSJ.pdf
Rule Changing; Gould and Soccer
1. The speed of the soccer game is grown from about 80 ball actions per player per match to about 120.
2. The last 30 years the average number of goals in top matches has decreases from about 4 to about 2 per match.
3. During EK and WK tournaments, the number of matches with at most 1 goal is more than 30%.

The increase of the quality of both the offensive skills and the defensive skills of the opponent has resulted in a significant leveling of the performances of elite teams.

High scores, like 4-3, are big exceptions.
What to do?

1. More actions within the penalty zone;
2. More goals;
3. More excitement for the fans (2-2 is usually much more exciting than 0-0);
4. Less influence of the referee on the final result.
Hypothesis

The **lower the level** of the competing teams the **more goals**, and the other way around.
Because the number of goals is very low in top matches, wrong decisions of the referee lead too many times to unacceptable situations:

These wrong decisions determine more and more the final result of the match.
The solution

Prohibit the goalkeeper from catching and clenching the ball with his hands.

( So punching away the ball with his hands or fists stays possible. )

Why is this a good solution?

1. Field players are already prohibited to clench the ball:
   the ball should always be ‘free’ during the play.
2. More rebounds of the keeper;
3. More shots on target;
4. More actions within the ‘16’;
5. Less ‘dead’ time! (NOW: usually less than 50 mins real playing time);
6. About 30% more goals.