

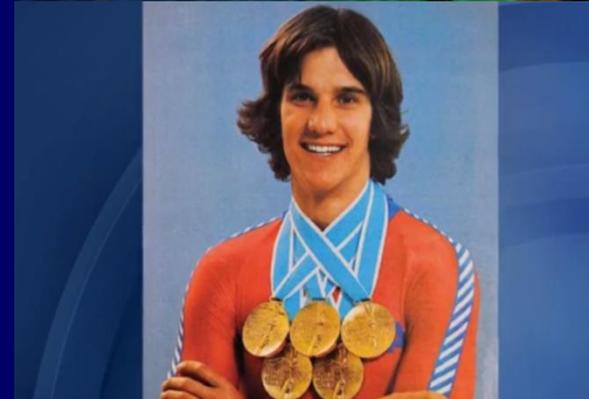
# Performance Densities in Elite Sports

Backgrounds  
Practice

Gerard Sierksma

University of Groningen  
ORTEC-Sports

April 12<sup>th</sup>, 2018



**“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**

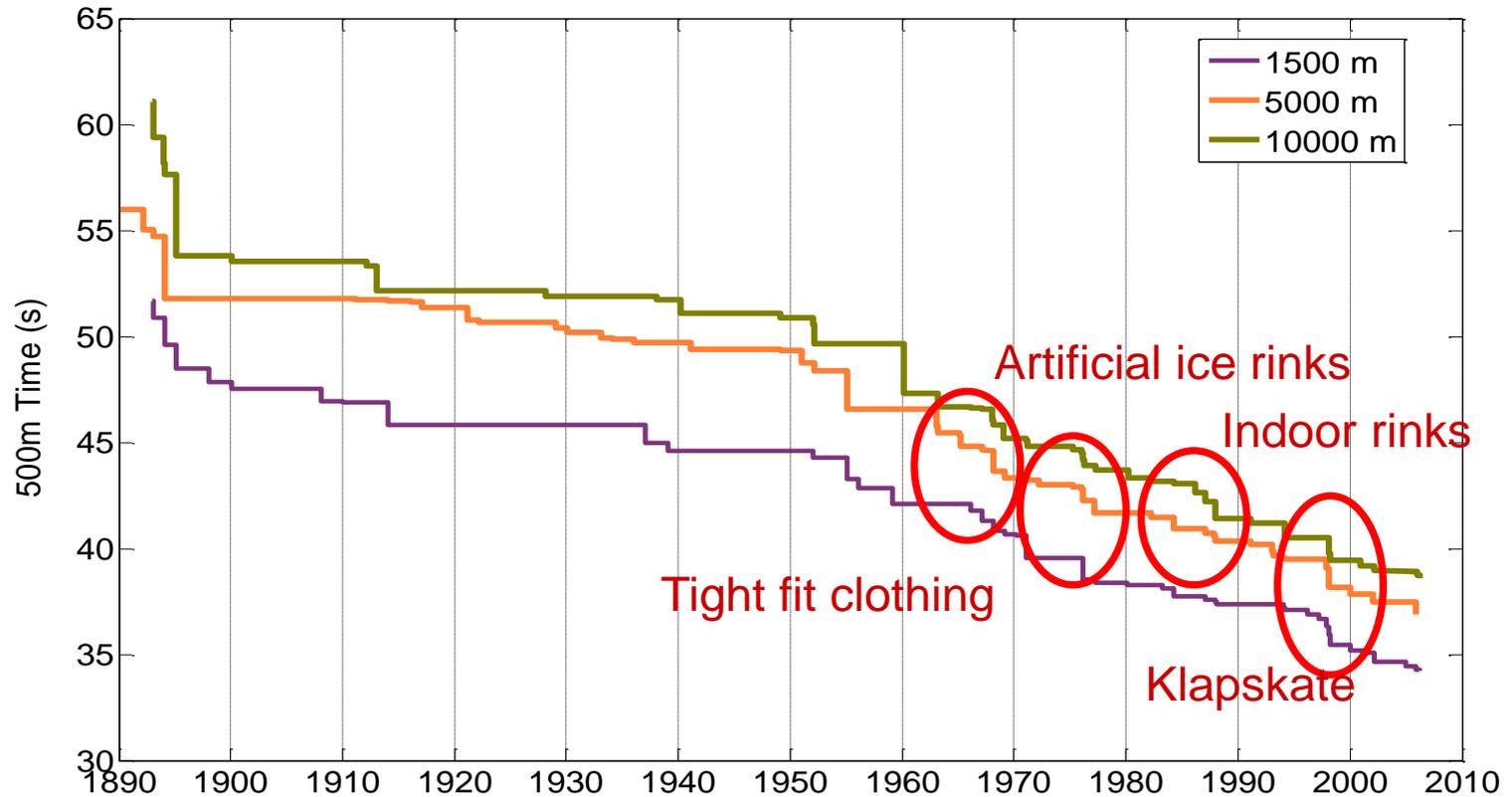
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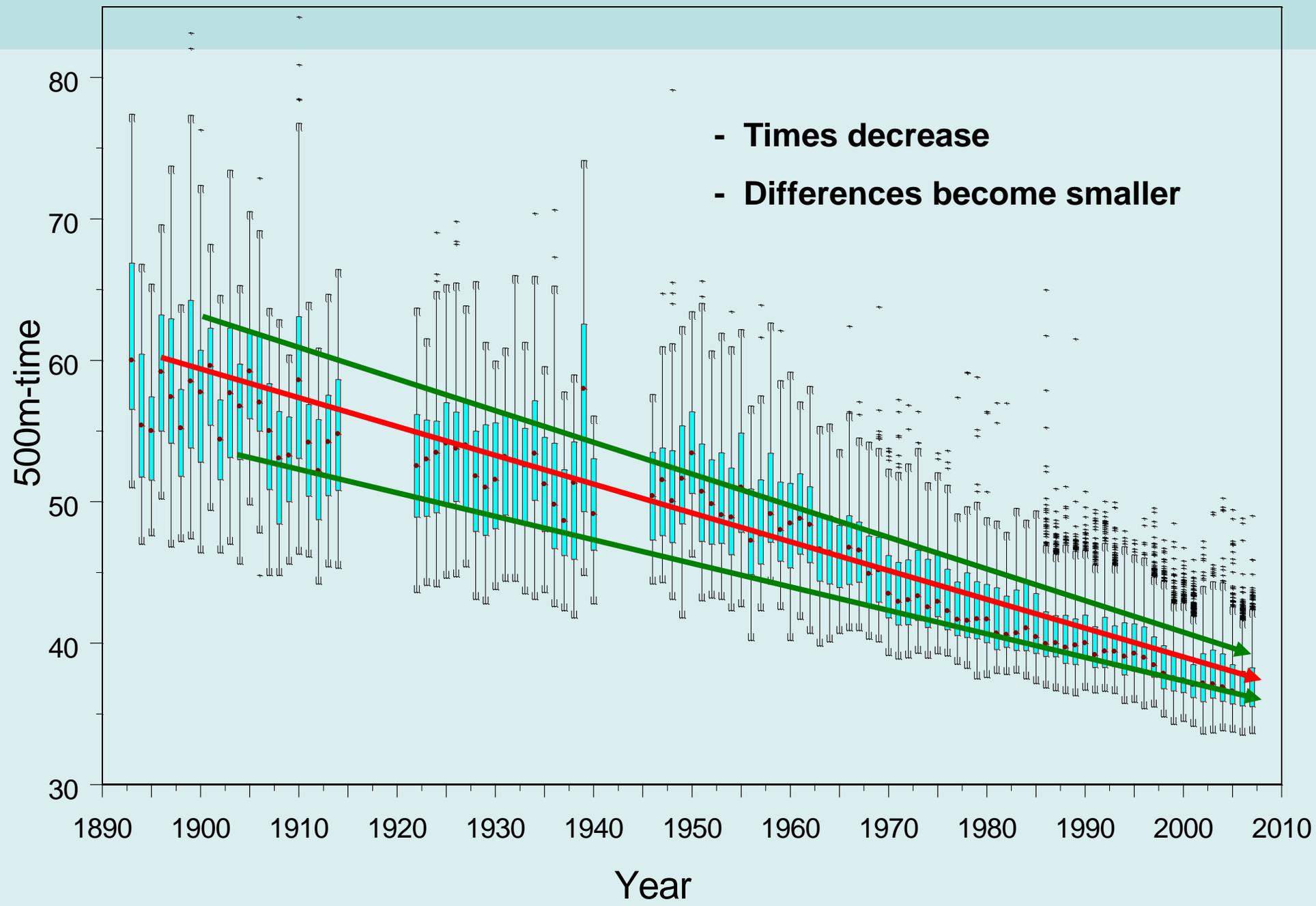
# Three parts:

- 1. Backgrounds**
- 2. Practice**
- 3. Future and research problems**

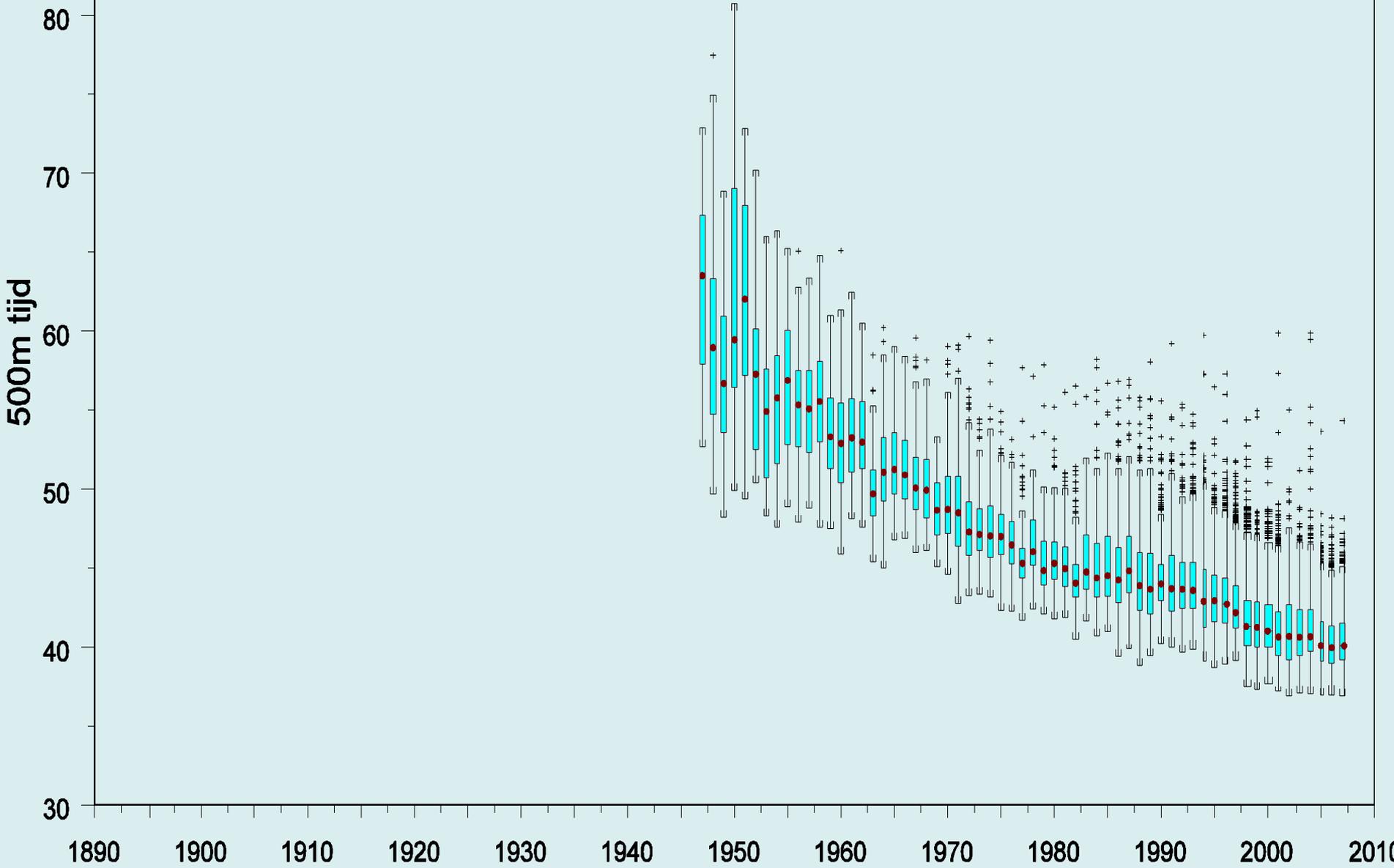
# Progress of the Men's World Records Speed Skating



# Development Skating Times



# Vrouwen



- <https://youtu.be/6gi1BEi0ceY>

- 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**.

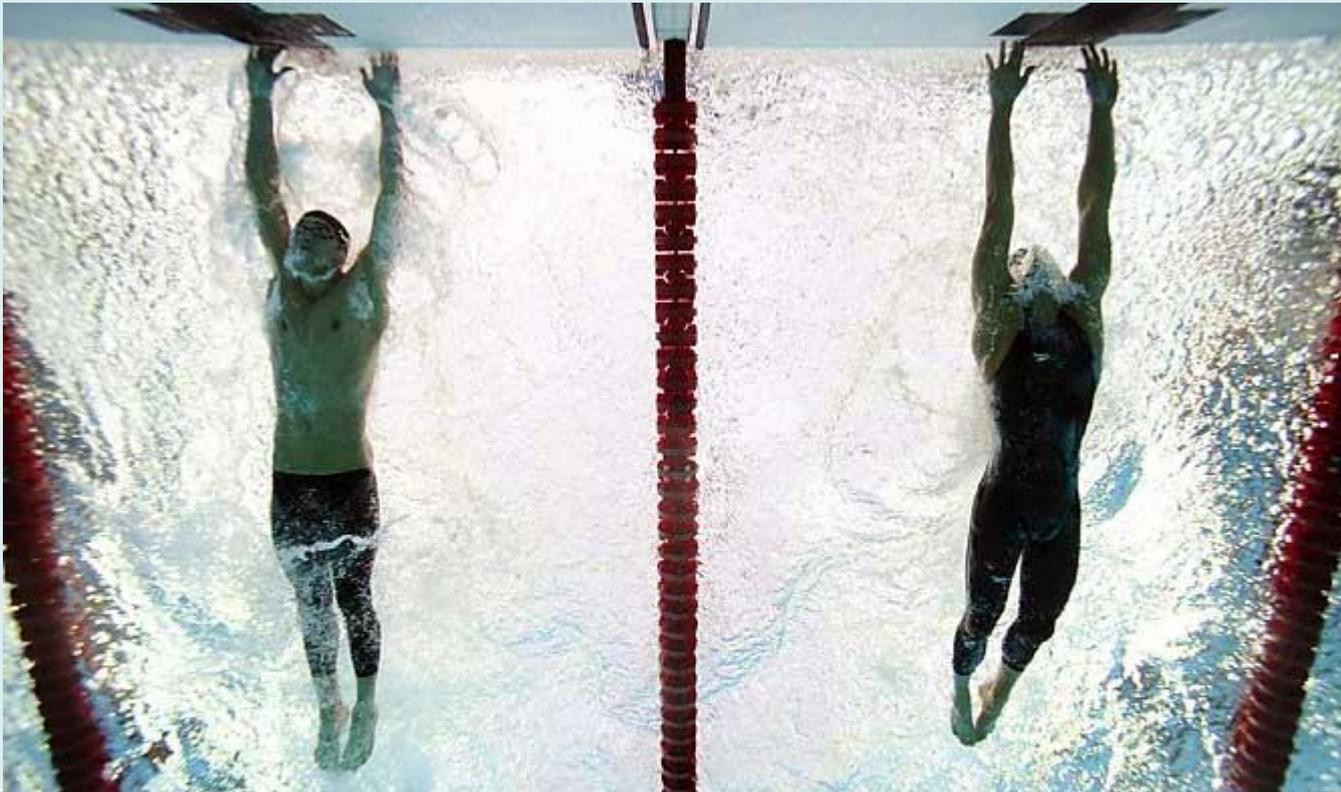


# Competition Crisis

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**



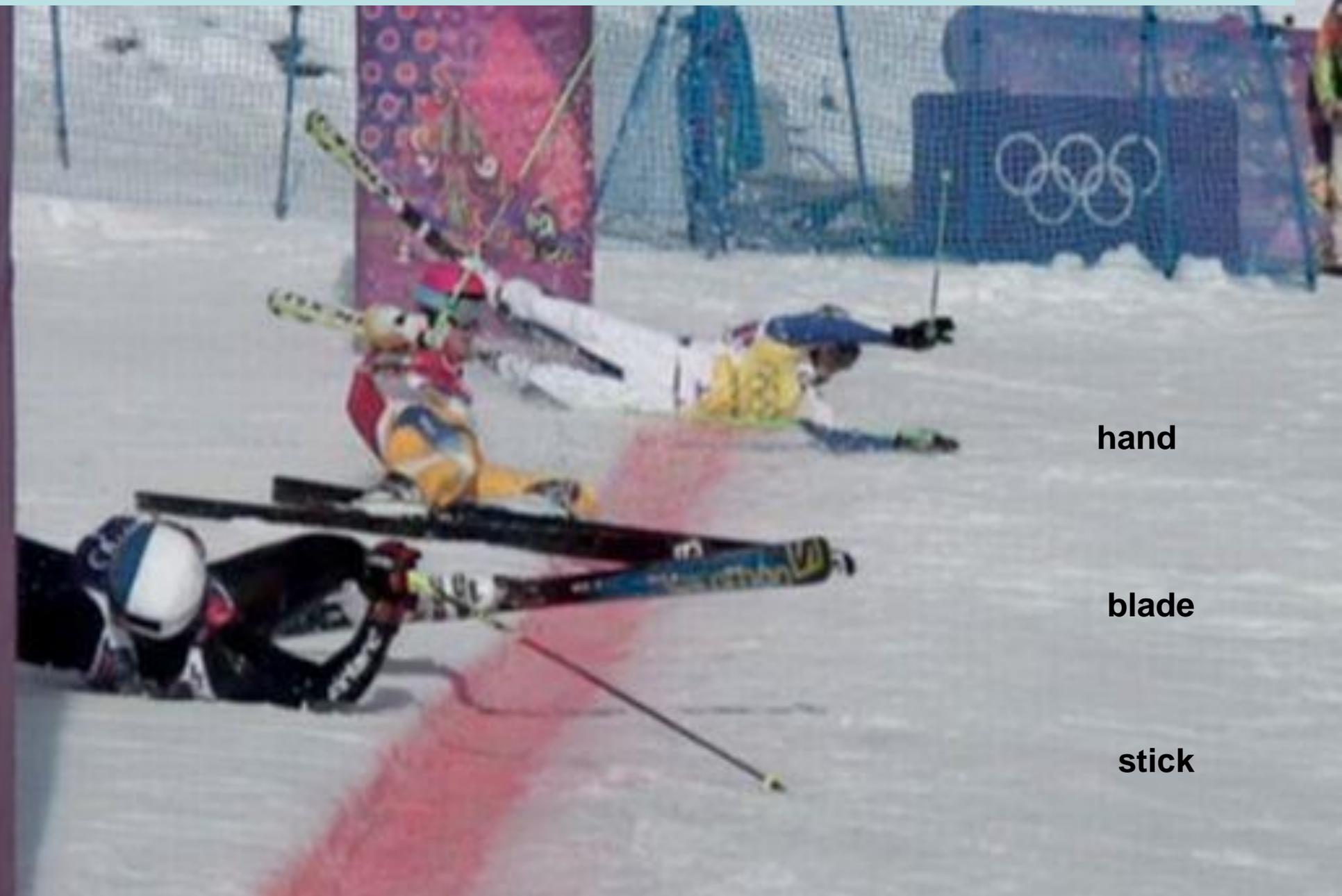


winner

Official Photofinish © RaceTECH

Grand National 2012 Steeple Chase  
**Is the finish line correct!!!**

**official** time system: all three **ex aequo**  
photo winner: top



hand

blade

stick

# Mens Skulls Rio 2016

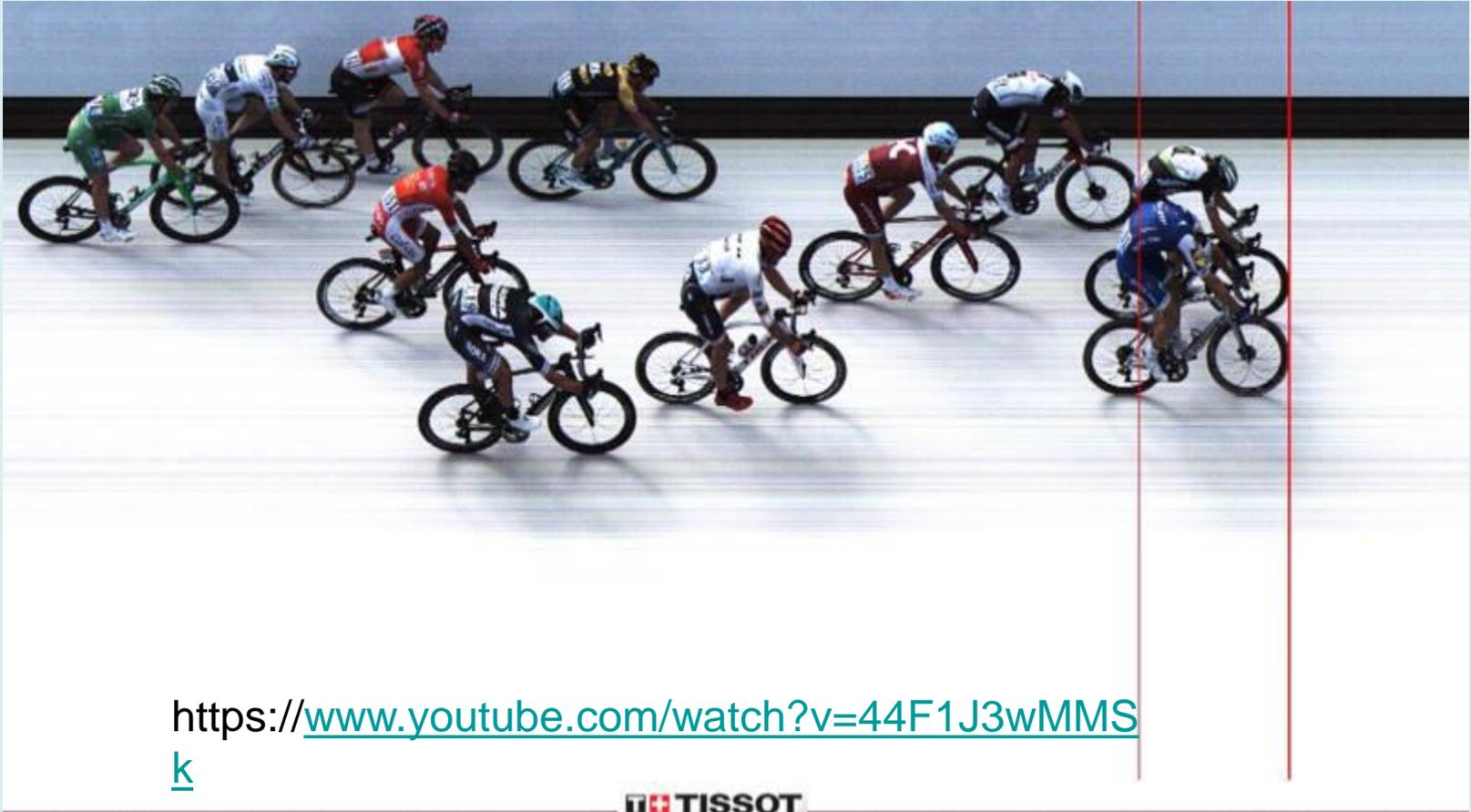


M. DRYSDALE	6:41.34
D. MARTIN	6:41.34
O. SYNK	6:44.10

 OMEGA

# Tour de France 2017, 7<sup>th</sup> 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!!!!**

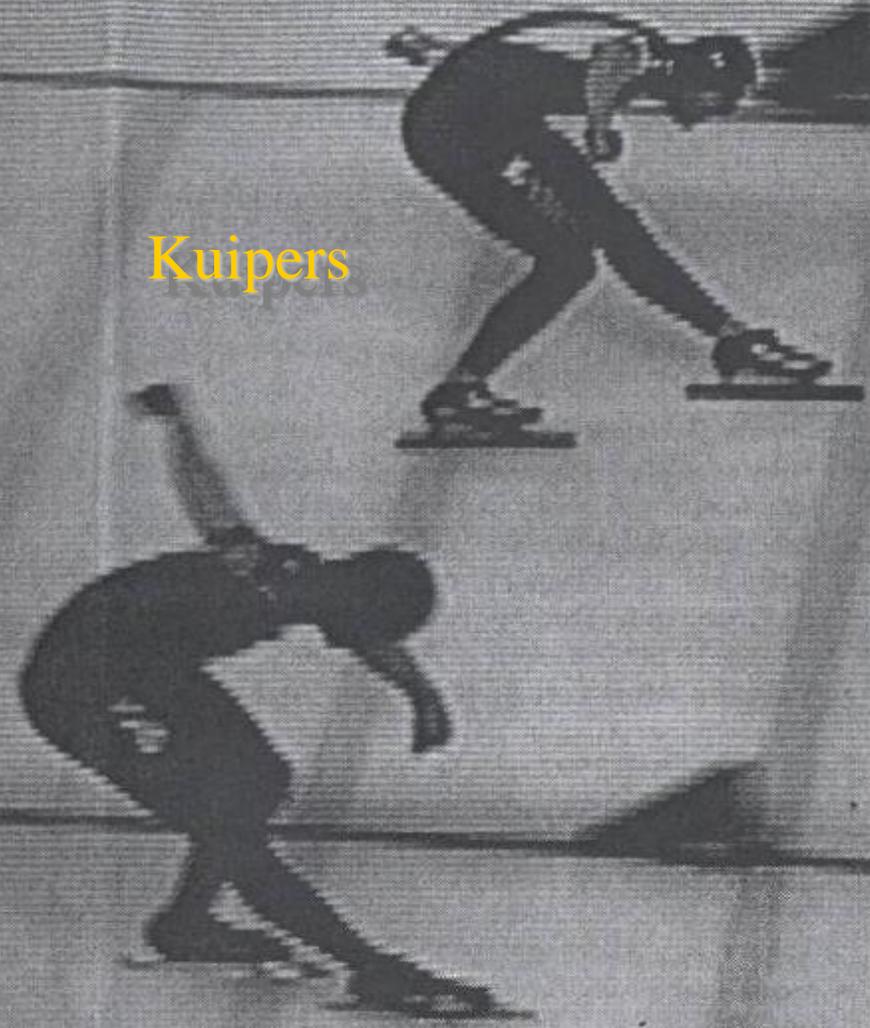
**An iconic picture**

Time system winner: Shani Davis.

Both athletes in the same 'pair'!!!!

Kuipers

Davis



If Simon Kuipers and Shani Davis  
would have skated  
**in different pairs,**  
then nobody would have 'seen' that  
Kuipers was the actual winner.

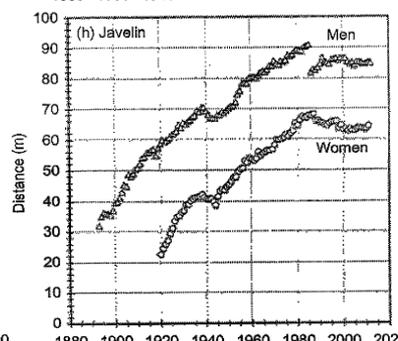
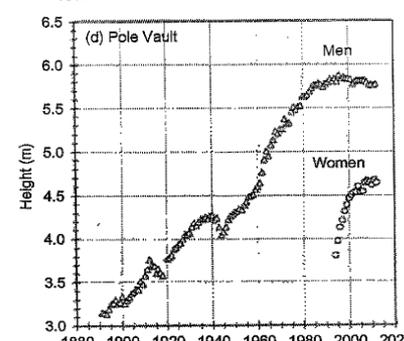
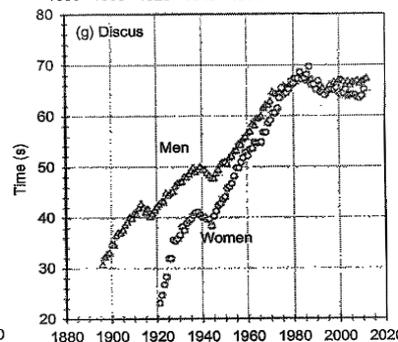
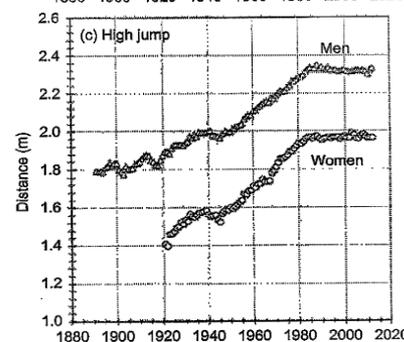
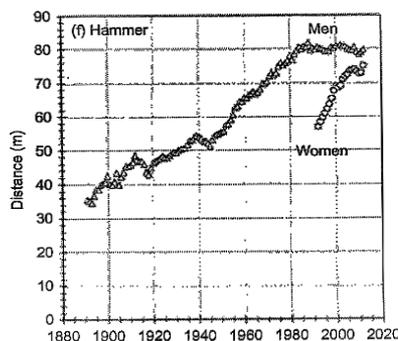
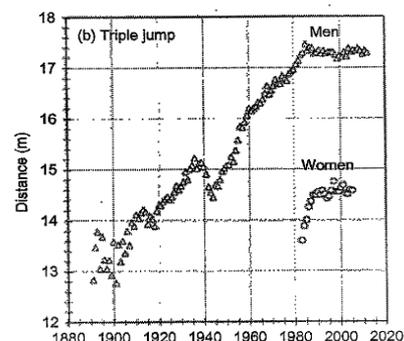
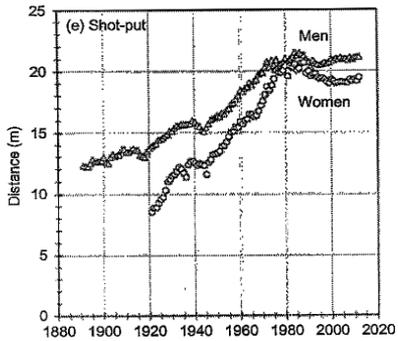
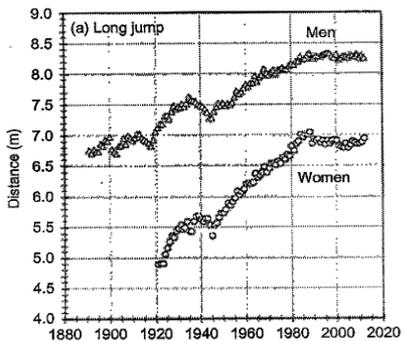
The Dutch speed skater, Koen Verweij, lost the 2014 Olympic gold medal with

**0.003 (!!!)** of a second.



Koen Verwey (left) loses GOLD with C





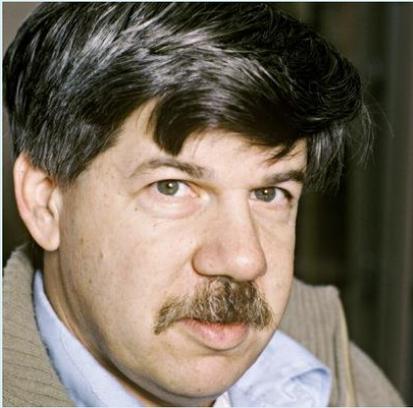
## Interesting paper in Journal of Sports Science

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

S.J. Gould. *Full House: the Spread of Excellence from Plato to Darwin*, Three Rivers Press, 1996.

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.

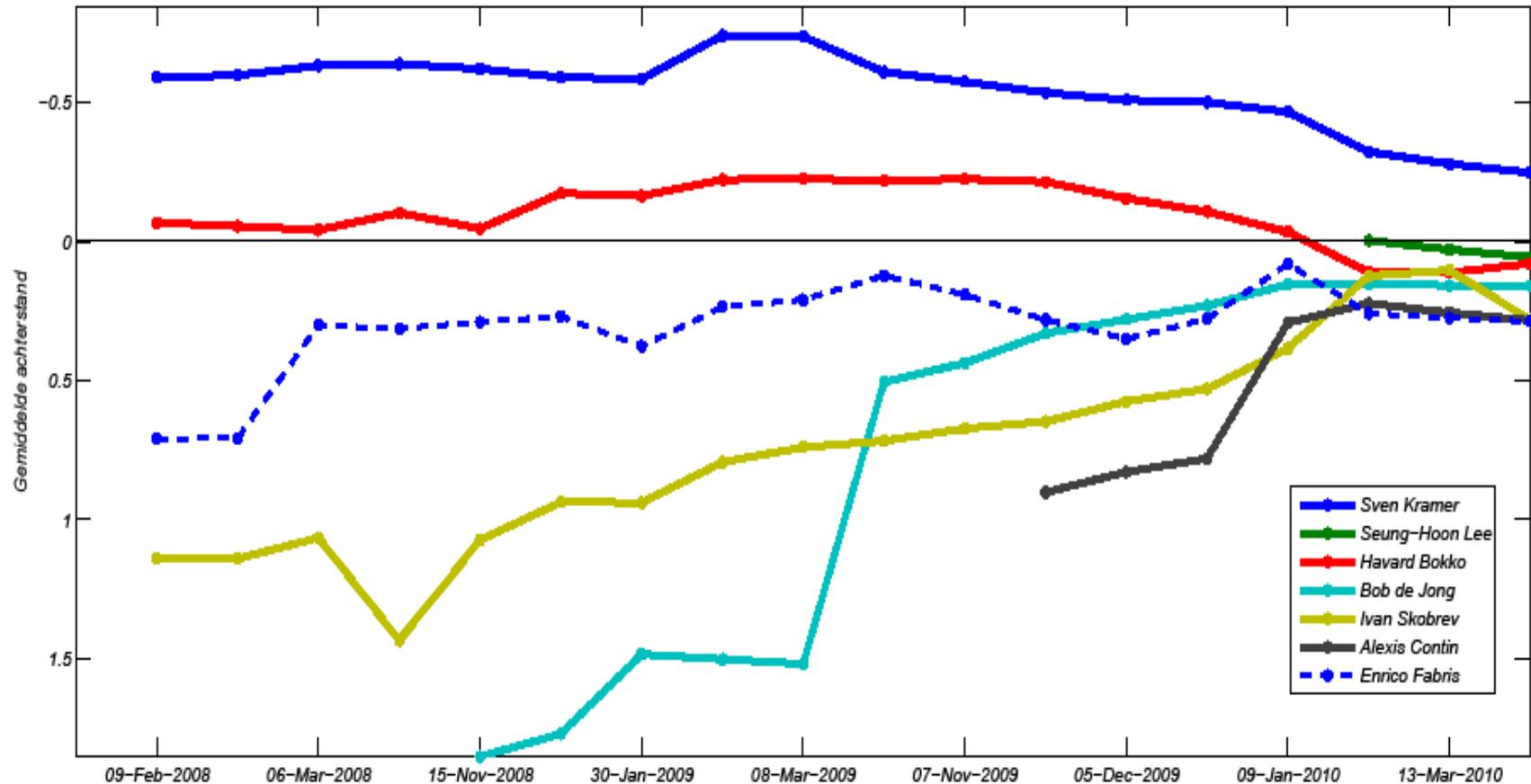
**40% is very high:**

**only the super stars could reach that level.**

General feeling of that time (newspapers/TV):

**performance level went down.**

TSS Speed Skating Ranking 5000 m



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.

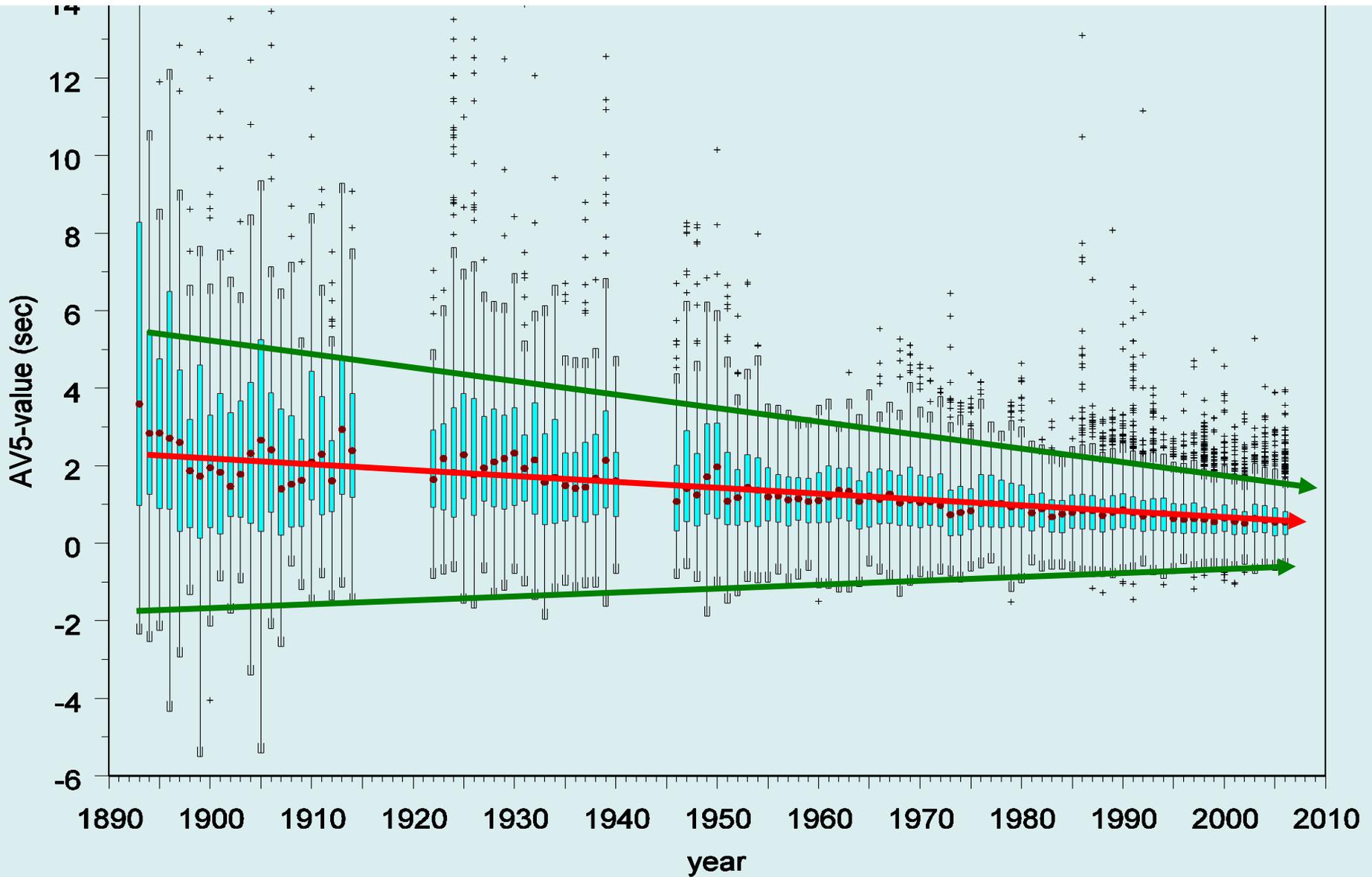
Athletes become **better and better**, not worse!

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

There is a wall, a limit to the improvements.

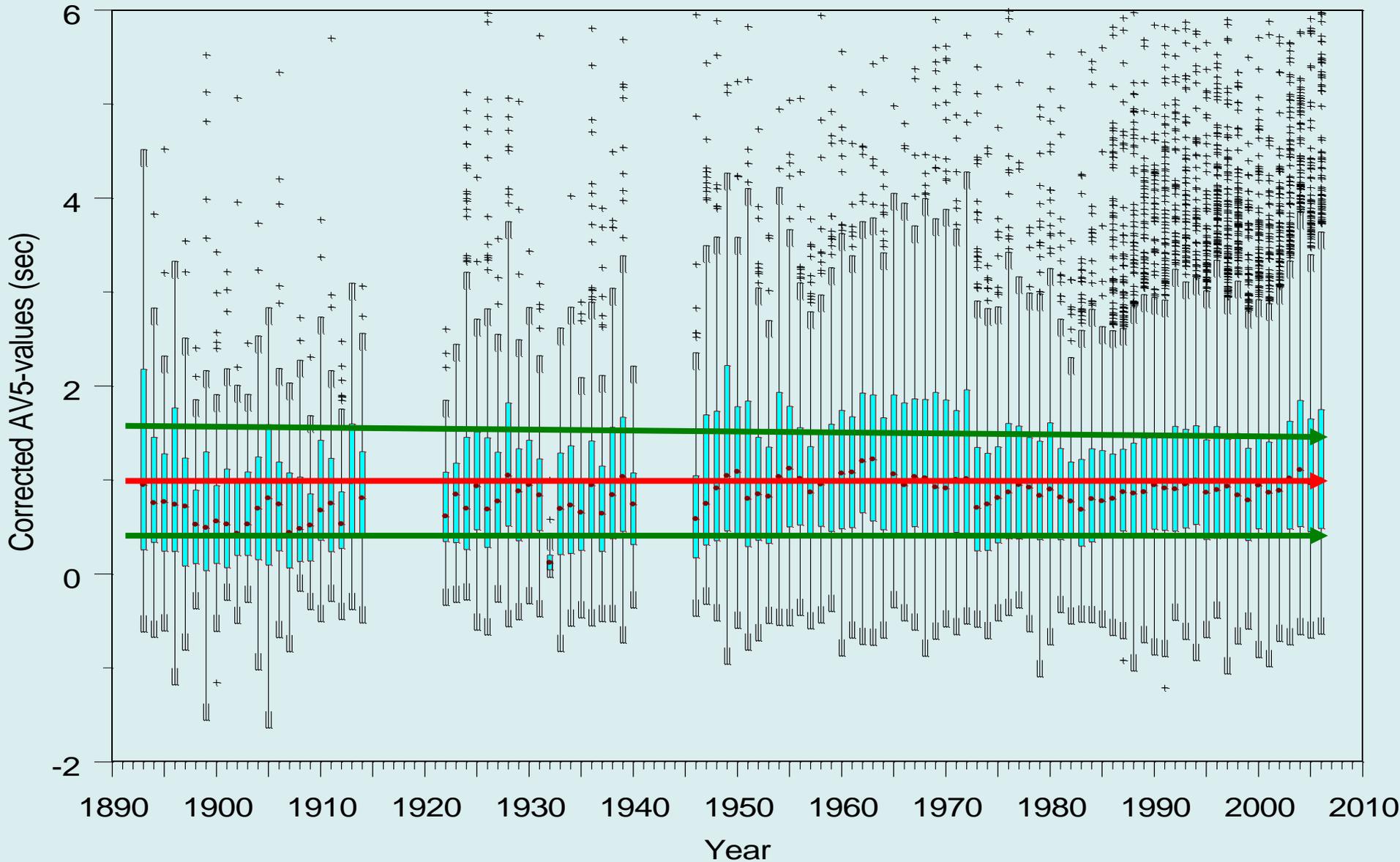
How to measure / quantify the Gould effect?

# 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:

**doping !!**

**Gould: a complex system collapses when the rules of the 'game' are not adapted.**

**So, the rules of the game need to be changed!!!**

Right  
decision:  
2x  
gold!!

# 2x goud na 2.713 meter

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



Dominique Gislin (links) uit Zwitserland en de Sloveense Tina Maze.

Foto EPA

Maze eindigde maandag als vierde op de supercombinatie, het onderdeel dat werd gewonnen door de Duitse

Maar Höfl-Riesch had gisteren haar dag niet. Ze ging slordig naar beneden en moest maar liefst 1,17 seconden toe-

heeft nog drie medaillekansen, want ze doet net als Maze aan vijf skidisciplines mee.

De Sloveense, die vier jaar geleden in

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 ijsneeuw iets zachter was geworden door de stijgende temperatuur (10 graden). Toen ze de finish passeerde stond de klok stil op 0,00.

Gislin had haar blik na de laatste tussentijd van Maze afgewend, ervan overtuigd dat ze zou verliezen. Vier jaar geleden, in Vancouver, kwam ze op de laatste sprong van de olympische afdaling ten val. Een jaar eerder won ze haar eerste afdaling in de wereldbeker door in dezelfde tijd te finishen als de Zweedse Anja Pärson. 'Ik keek weg. Toen keek ik omhoog. Ik zag nul. Nul? Dat betekent dat het goed zit.'

**“**Beter twee op de eerste plaats dan een die met eenhonderdste seconde verliest

Tina Maze winnares uit Slovenië

Maze zag een ander nummer op het scorebord verschijnen. Achter haar naam stond '1'. Ze smeet haarskibril in een gebaar van vreugde hoog de lucht in. 'Ik was gewoon blij. De rest is onbelangrijk.'

In het vak voor de klasmentsleiders keken de vrouwen vervolgens samen hoe de resterende 21 deelnemers zich stuk beten op hun tijd, ook van wege de steeds slechter wordende piste. Bij Gislin vloeiden de tranen voordat de uitslag officieel was. Maze straalde van geluk. Ze is de eerste Sloveense met goud op de Winterspelen.

'Beter twee op de eerste plaats dan een die met eenhonderdste seconde verliest', zei Maze. Ze is er niet rouw om dat in de skisport het verschil tu-

# 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<sub>(m/w)</sub>, 1000m<sub>(m/w)</sub>, 1500m<sub>(m/w)</sub>, 3k<sub>(w)</sub>, 5k<sub>(m)</sub> 3 start positions

5k<sub>(w)</sub> en 10k<sub>(m)</sub> 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-thousandths 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 *prio* gold-silver-bronze.

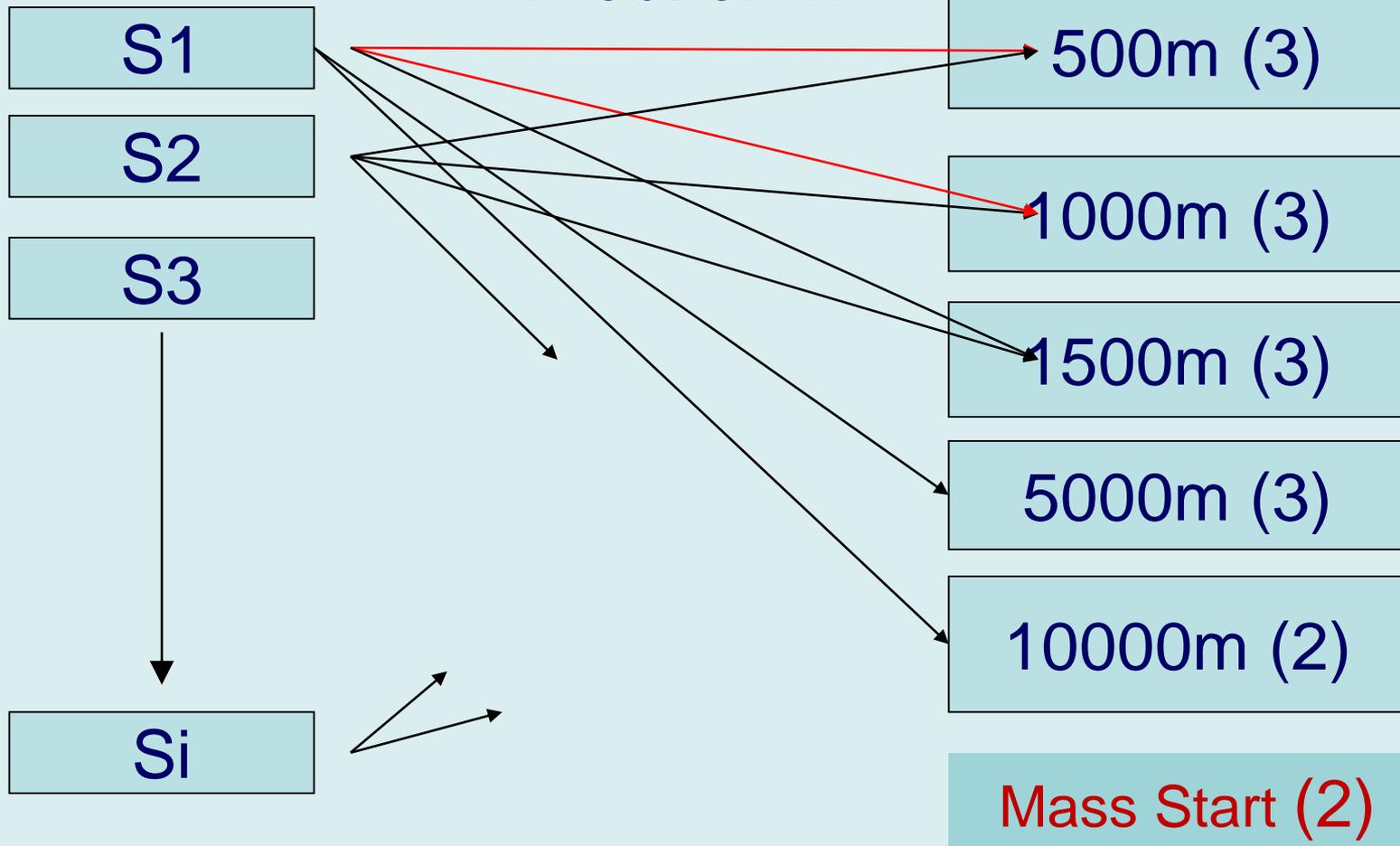
# Schematic model

max 10 skaters

Skaters

Distances  
tickets

Prob. of ...



# Model

## variables and parameters

### Parameters:

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

### Decision variables:

$X_{ij} = 1$  skater  $i$  starts on dist.  $j$ ;

$0$  otherwise.

$Z_i = 1$  skater  $i$  is selected;

$0$  otherwise.

# Integer linear optimization model

$$\text{Max} \sum_i \sum_j c_{ij} x_{ij}$$

$$\sum_i x_{i,500m} \leq 3$$

$$x_{ij} \in \{0,1\}$$

$$\sum_i x_{i,1000m} \leq 3$$

$$x_{ij} \leq z_i (\geq \text{integer}) \quad \forall i, j$$

$$\sum_i x_{i,1500m} \leq 3$$

$$\sum_i z_i \leq 10$$

$$\sum_i x_{i,5000m} \leq 3$$

$$\sum_j x_{ij} \geq z_i \quad \forall i$$

$$\sum_i x_{i,10000m} \leq 2$$

Note the logical restriction(s).

# Results Vancouver 2010

	Optimal	KNSB
500m	Kuipers	Kuipers
	Groothuis	Bos
	Smeekens	Smeekens
	Mulder	Mulder
1000m	Kuipers	Kuipers
	Groothuis	Groothuis
	Tuitert	Tuitert
	Ket	Bos
1500m	Kramer	Kramer
	Groothuis	Groothuis
	Tuitert	Tuitert
	Ket	Kuipers
5000m	Kramer	Kramer
	De Jong	De Jong
	Blokhuizen	Blokhuizen
10000m	Kramer	Kramer
	De Jong	De Jong
	Verheijen	Van de Kieft

**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).

# Performance matrix (women)

## Vancouver 2010

**Table 4.4.** Performance matrix,  $PM^3$  ( $PM^6$ ), December 2010, Dutch female skaters (in %)

	500m	1000m	1500m	3000m	5000m
Annette Gerritsen	10 (83)	69 (93)	9 (22)		
Natasja Bruintjes	0 (0)	4 (17)	0 (1)		
Diane Valkenburg			5 (27)	0 (1)	
Anice Das	0 (0)				
Elma Vries			11 (22)	0 (4)	0 (8)
Gretha Smit				0 (0)	0 (0)
Ireen Wust	0 (0)	1 (6)	29 (48)	1 (27)	
Jorien Voorhuis		0 (0)	0 (0)		0 (1)
Laurine Riessen	0 (1)	2 (10)	0 (1)		
Lisette Geest					
Margot Boer	1 (74)	8 (64)	16 (4)		
Marianne Timmer	1 (19)	33 (65)			
Marrit Leenstra		0 (0)	0 (0)		
Moniek Kleinsman				0 (1)	
Paulien Deutekom			0 (0)		
Renate Groenewold				0 (0)	0 (14)
Sanne Star	0 (0)				
Thijsje Oenema	0 (1)	0 (0)			

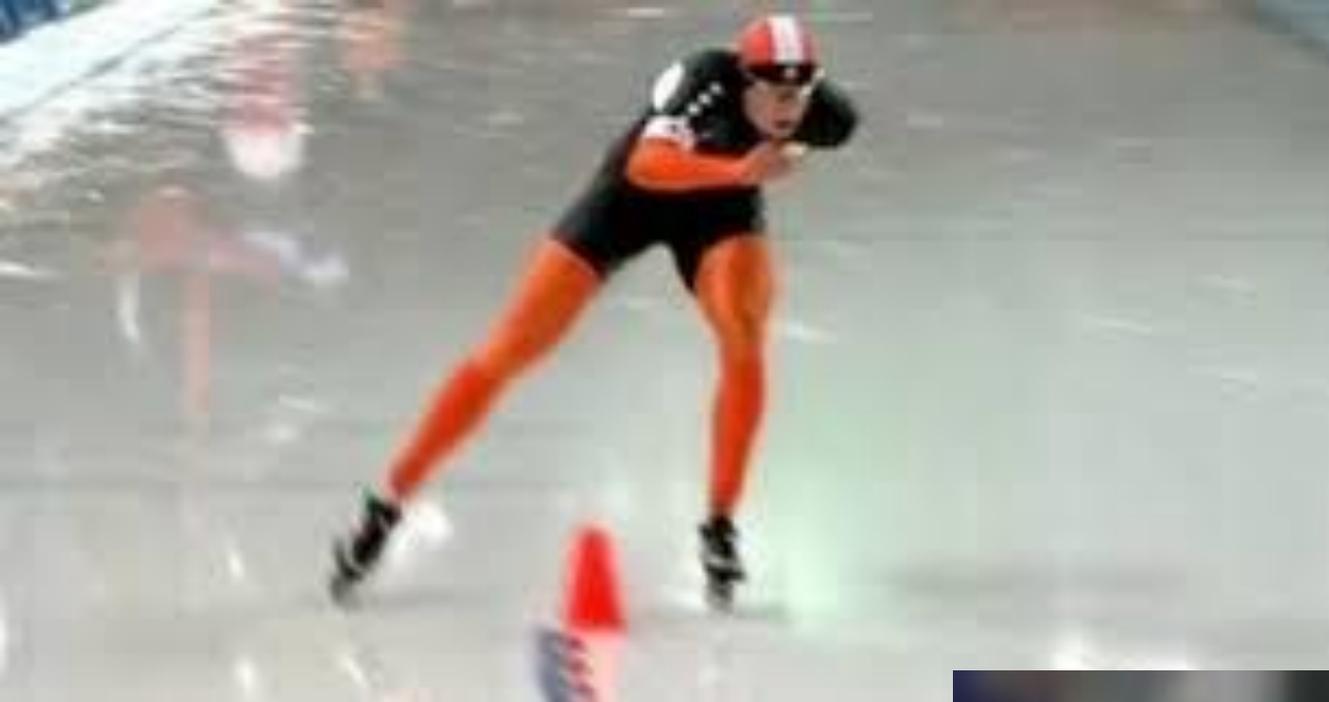
# Performance matrix (men)

## Vancouver 2010

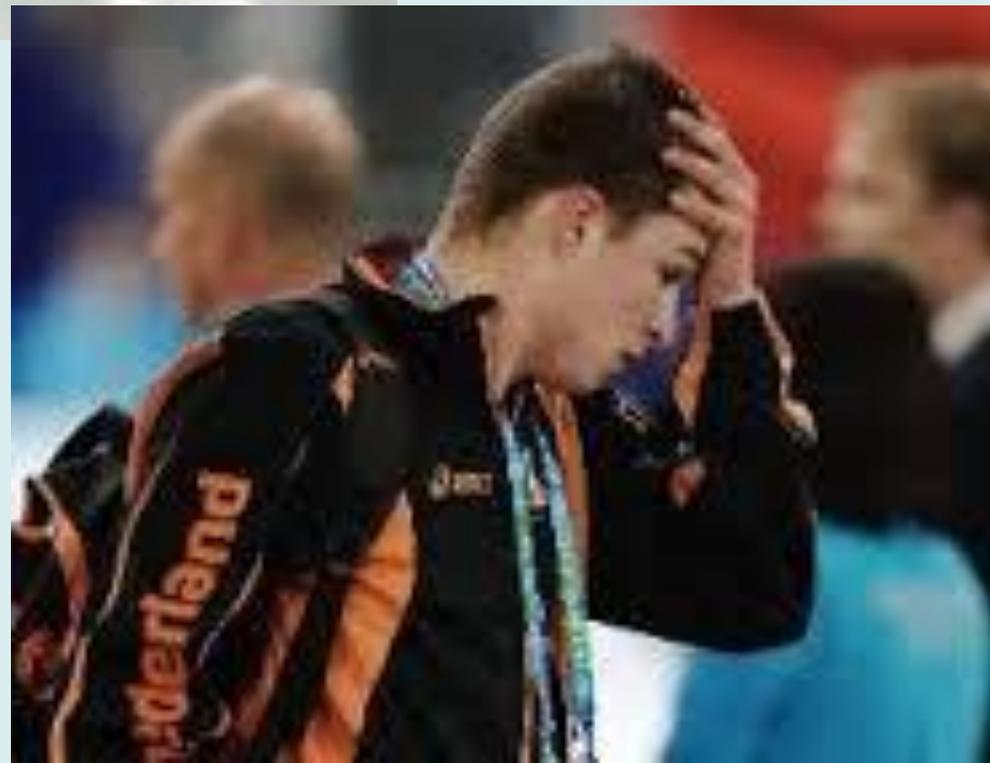
**Table 4.3.** Performance matrix,  $PM^3$ , December 2010, Dutch male skaters (in %)

	500m	1000m	1500m	5000m	10000m
Bob de Jong				71	94
Ben Jongejan				0	0
Bob Vries				4	0
Remco Olde Heuvel		0	4		
Koen Verweij				0	0
Simon Kuipers	0	17	0		
Stefan Groothuis	0	77	16		
Lars Elgersma		1	0		
Jan Blokhuijsen				16	0
Carl Verheijen				10	13
Erben Wennemars	0	0	0		
Rhian Ket		0	10		
Wouter Olde Heuvel				0	0
Jacques Koning	0	0			
Jan Bos	0	2	0		
Jan Smeekens	10	0			
Mark Tuitert	0	9	17		
Sven Kramer			0	96	100
Ronald Mulder	5	0			
Arjen Kieft					0

**..... 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

Rank	NOC	Gold	Silver	Bronze	Total
1	 Russia (RUS)*	13	11	9	33
2	 Norway (NOR)	11	5	10	26
3	 Canada (CAN)	10	10	5	25
4	 United States (USA)	9	7	12	28
5	 Netherlands (NED)	8	7	9	24
6	 Germany (GER)	8	6	5	19
7	 Switzerland (SUI)	6	3	2	11
8	 Belarus (BLR)	5	0	1	6
9	 Austria (AUT)	4	8	5	17
10	 France (FRA)	4	4	7	15
11	 Poland (POL)	4	1	1	6

# Pyongyang 2018

Plaats	Land	NOC	Goud	Zilver	Brons	Totaal
1	<a href="#">Noorwegen</a>	NOR	14	14	11	39
2	<a href="#">Duitsland</a>	GER	14	10	7	31
3	<a href="#">Canada</a>	CAN	11	8	10	29
4	<a href="#">Verenigde Staten</a>	USA	9	8	6	23
<b>5</b>	<a href="#">Nederland</a>	NED	8	6	6	<b>20</b>
6	<a href="#">Zweden</a>	SWE	7	6	1	14
7	<a href="#">Zuid-Korea</a>	KOR	5	8	4	17
8	<a href="#">Zwitserland</a>	SUI	5	6	4	15
9	<a href="#">Frankrijk</a>	FRA	5	4	6	15
10	<a href="#">Oostenrijk</a>	AUT	5	3	6	14
11	<a href="#">Japan</a>	JPN	4	5	4	13
12	<a href="#">Italië</a>	ITA	3	2	5	10
13	<a href="#">Olympische atleten uit Rusland</a>	OAR	2	6	9	17
14	<a href="#">Tsjechië</a>	CZE	2	2	3	7
15	<a href="#">Wit-Rusland</a>	BLR	2	1	0	3
16	<a href="#">China</a>	CHN	1	6	2	9
17	<a href="#">Slowakije</a>	SVK	1	2	0	3
18	<a href="#">Finland</a>	FIN	1	1	4	6
19	<a href="#">Groot-Brittannië</a>	GBR	1	0	4	5
20	<a href="#">Polen</a>	POL	1	0	1	2
21	<a href="#">Hongarije</a>	HUN	1	0	0	1
21	<a href="#">Oekraïne</a>	UKR	1	0	0	1
23	<a href="#">Australië</a>	AUS	0	2	1	3
24	<a href="#">Slovenië</a>	SLO	0	1	1	2
25	<a href="#">België</a>	BEL	0	1	0	1

# 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 tourmnaments, 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**

**0-0 1-0 0-1**

**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.**