Understanding Distributions of Chess Performances

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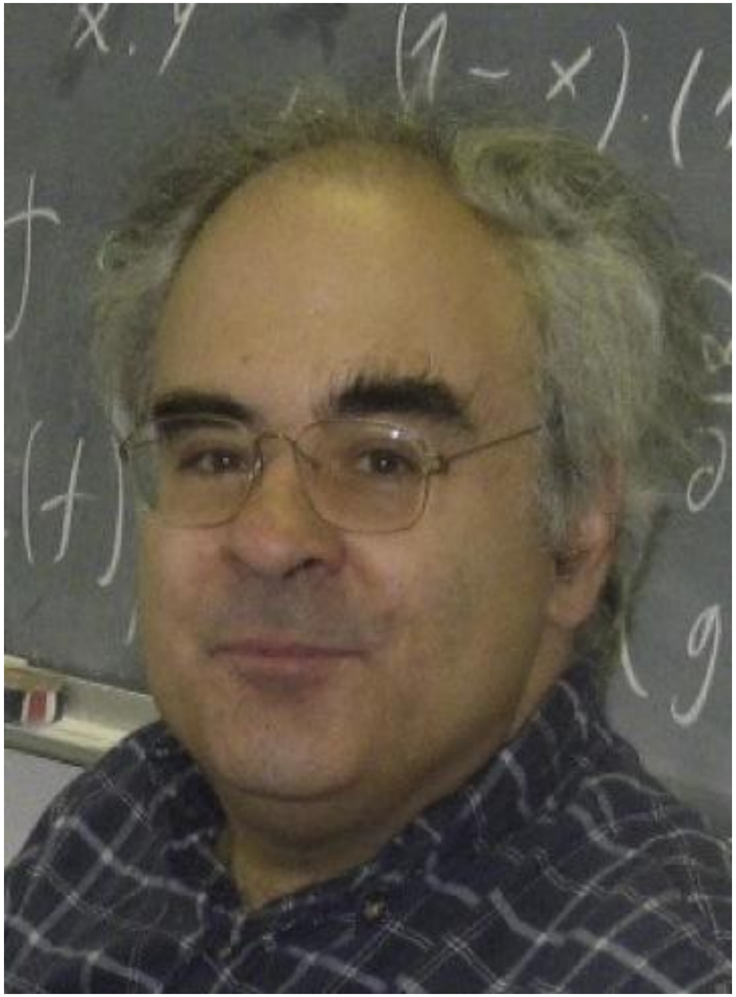
(alternate slides with more detail than ACG13 talk)

Part 1: Population Model for 2200+ Players.
Part 2: Average Error per Tournament Category by Year.
Part 3: Intrinsic Performance Ratings.
Part 4: Distributions Of and Within Tournaments.



Kenneth Regan

Bartlomiej Macieja

Performances Measured By Elo Ratings

- FIDE Elo System started in 1971.
- Ratings are relative, no intrinsic meaning to 2200, 2300, 2400, 2500, 2600, 2700, 2800…
- Does “2700” mean “truly in the world elite” or an absolute level of skill?
- Fischer and Karpov only 2700+ players thru 1981.
- 47 2700+ on Nov. 2011 FIDE Elo list. Inflation?
- Could the Laurent Fressinet of 2011 have beaten the Anatoly Karpov (2695) of 1981? Nigel Short at 2698? What tests can we try?

Backstory

- A sequence of papers on ‘Assessing Decision Makers’
  - Reference Fallible Decision Makers (2002, 2003)
  - (Deeper) Model Endgame Analysis (2003, 2005)
  - Extension of the concept to pre-EGT Chess (2007)
  - Skill Rating by Bayesian Inference (2009) ... IEEE CIDM ‘09
  - Performance and Prediction, (2009) ... ACG12, Pamplona
  - Intrinsic Chess Ratings (2011) ... AAAI-11, San Francisco
- Topics
  - The creation of a Skilloscope to rank players
  - Comparison of and correlation with ELO scales
  - Detection of plagiarism ... and ELO Scale instability

Our own previous work

- [DiFatta-Haworth-Regan, ICDM 2009]: Bayesian iteration yields correspondence between Elo and model with a single skill parameter. Engine Toga II in 10-PV mode, depth 10.
- [Haworth-Regan-DiFatta, ACG 12, 2009]: Reference Fallible Agent modelling, application to controversial cases.
- [Regan-Haworth, AAAI 2011]: 2-parameter model using Rybka 3 in 50-PV mode, depth 13. Multinomial Bernoullli-trial not Bayesian model. Described further below.

Related Work

- Matej Guid and Ivan Bratko, 2006—2011
  - Focused on World Championship matches
  - Crafty to depth 12, recently other engines incl. Shredder and Rybka 2 to depth 12, and Rybka 3 to depth (only) 10.
  - Reliable for relative rankings.
- Charles Sullivan, www.truechess.com
  - All games by WC's, 617,446 positions, Crafty 20.14 (modified) for 6 min. on single thread, Rybka 2.32a used to check possible blunders.
- User "deka" posts at http://rybkaforum.net/cgi-bin/rybkaforum/topic_show.pl?tid=5850 Victorian era players, Rybka 3 depth 14 in 4-PV mode.
- Jeff Sonas, www.chessmetrics.com & Kaggle, others…

The focus today

- the question of *ELO Inflation*
- common remarks about the FIDE ELO scale
  - *ELO 2700* does not mean what it used to mean
  - *ELO 2700* is not worth what it was
    -
- Three assessments of the inflation question
  - Population dynamics
  - ‘Average Error’ in categorised FIDE tournaments
  - Parametric models of Virtual ELO players

Three Kinds of Tests

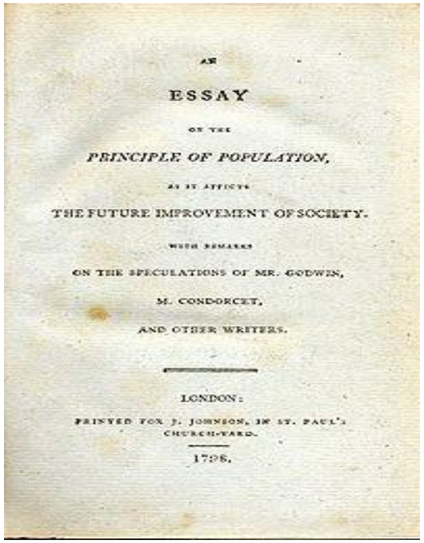
(well, two are based on computer analysis)

1. Population Models
   - Predict deflation insofar as players expire with more zero-sum points than they entered with.
   - Many obey simple equations (Verhulst 1800s).
2. Average Error (AE) from computer analysis of games in Single-PV mode on large scale.
3. Intrinsic Ratings from Multi-PV analysis.
   - Applicable to smaller sets of games, e.g. performances in small RRs or 9-round Swisses.

Summary Results

- Population Analysis
  - the figures do not provide evidence of inflation
  - Nor do they disprove the ‘inflation theory’ but ...
    - They do exclude two sources of inflation
- ‘Average Error’ calculations on FIDE-rate tournaments
  - Single-PV analysis singles out ELO-levels of competence
  - show some signs of deflation in the last 20 years
    - i.e. Improving standards at ELO Level ‘E’ (for high ‘E’)
- Modelling players using statistical regression:
  - Multi-PV analysis acknowledging most relevant options
  - The ‘optimal parameters’ are reasonably stable over time

1. Population Studies



AN

ESSAY

ON THE

PRINCIPLE OF POPULATION,

AS IT AFFECTS

THE FUTURE IMPROVEMENT OF SOCIETY.

WITH REMARKS

ON THE SPECULATIONS OF MR. GODWIN,

M. CONDORCET,

AND OTHER WRITERS.

LONDON:

PRINTED FOR J. JOHNSON, IN ST. PAUL'S
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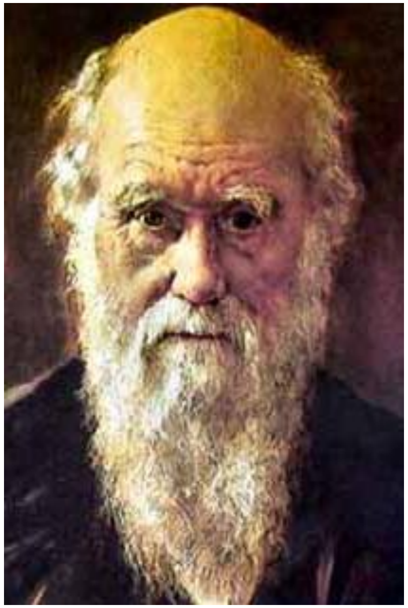
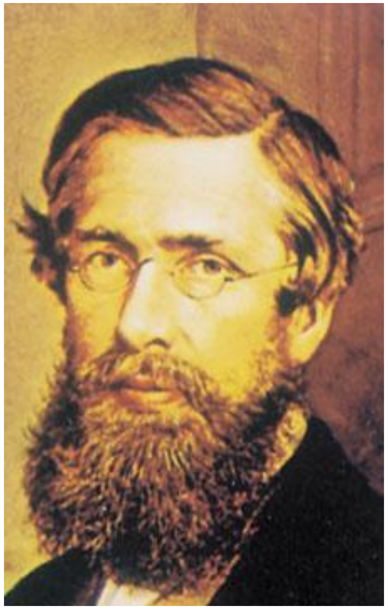
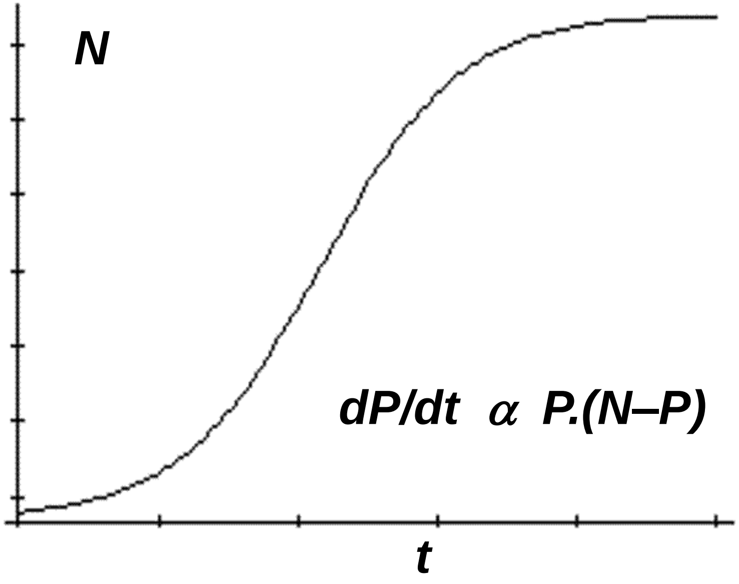






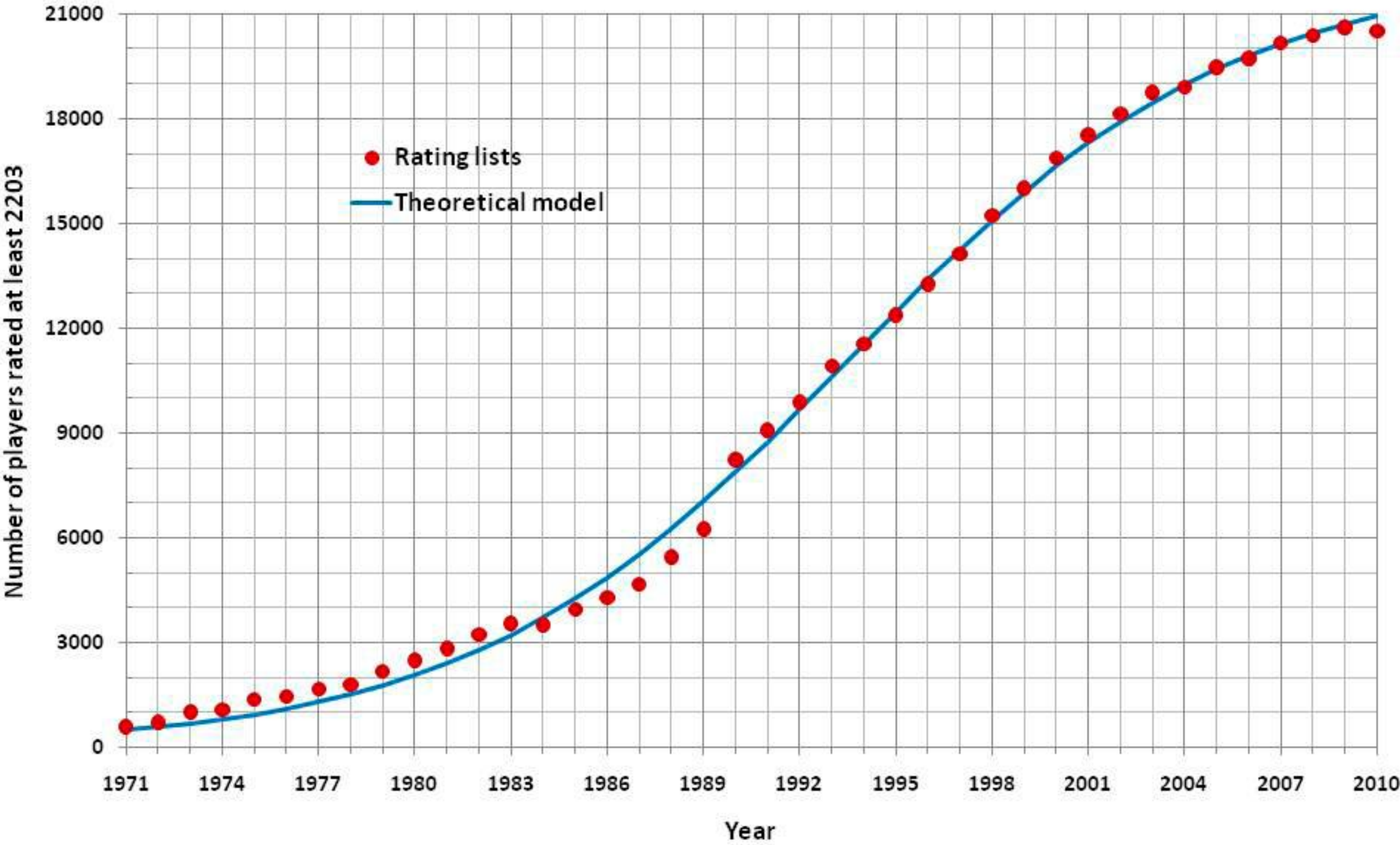
Results 1. Population Model

- Has the increase in 2200+ players been due to rating inflation or other factors?
- Population models already important in re-basing Elo system on a logistic curve.
- Simple Verhulst [1838] model (N = pop.): $dN/dt = aN - bN^2$. Solution:

$$N(t) = M/(1 + ae^{-bt})$$

- Actual data and curve fitting a,b,M overleaf.
- Considerable agreement suggests other factors minimal, no inflation.
- Owing to past use of 2200 as rating floor and rounding, 2203 used as cutoff.

Figure 1: Growth of number of players rated at least 2203 since 1971



Results 2. Single-PV Experiments

- Rybka 3.0 1-cpu run in single-PV mode to fixed reported depth 13 (over 4-ply base?)
- Larry Kaufman estimated depth 14 = 2750.
- Common estimate 70-75 Elo/ply in this range, so ours would be 2650-2700, maybe best guessed as 2900 in opening sliding down to 2400 in endgames.
- Run manually in Arena GUI (versions 1.99, 2.01).
- Reproducible except when Rybka stalls and must be manually re-started, clearing hash.

Tournaments By Category Experiment

- **Every** tournament given category >= 11 by ChessBase Big 2009 database + TWIC.
- Skip turns 1—8, ignore positions with Rybka advantage > 3.00 centipawns for either side at previous ply, and skip (immediate) repetitions.
  - If eval dips back under 3.00, charge a once-only “error” as the difference from 3.00.
- Over **4 million** moves analyzed (3,770,854 retained, 260,404 discarded not counting moves 1--8).
- Can be improved but large data → firm results.

Part of 3-Year Larger Project

- On just two 4-core PC's, Regan has done:
  - Every WC, WWC, and men's Candidates' match.
  - Every major tournament (some 1950--70 to do).
  - Large selects from every Olympiad, some entire.
  - Large selects from major Swiss events.
  - All ICGA WCC tourneys; some engine matches.
  - Amber and other Rapid; Blitz; Correspondence; PAL/CSS Freestyle; KO, Youth---close to the entire history of chess except national leagues.
- Serves as Scientific Control for Anti-Cheating (Multi-PV) work (hence some parts are sensitive).

Average Error

- When played move ≠ Rybka's first move, error = max(value – value(next position), 0).
- Perhaps better to use value(next at depth 12), but this keeps it simple.
- Role of Single-PV as imitating human spot-checking for cheating and scientific control led Regan to cut corners on Guid-Bratko methods.
- Hence call stat AE for Average Error, not AD.
- Rybka 3 1-cpu x 4 core threads on just two 4-core PC's to d=13; [GB] stopped at depth 10.

Average Error

```
Eval for PTM: Error(.cp)/#moves = AE
-1.00 -- -0.91: 2370.72 / 14312 = 0.1656
-0.90 -- -0.81: 2537.31 / 16929 = 0.1499
-0.80 -- -0.71: 2357.24 / 17982 = 0.1311
-0.70 -- -0.61: 2794.65 / 23956 = 0.1167
-0.60 -- -0.51: 3525.21 / 32718 = 0.1077
-0.50 -- -0.41: 3155.00 / 33945 = 0.0929
-0.40 -- -0.31: 4203.85 / 50242 = 0.0837
-0.30 -- -0.21: 4990.28 / 65310 = 0.0764
-0.20 -- -0.11: 6346.10 / 89116 = 0.0712
-0.10 -- -0.01: 5745.90 / 84775 = 0.0678

 0.00 --  0.00: 7931.69 / 95112 = 0.0834

 0.01 --  0.10: 4927.55 / 87933 = 0.0560
 0.11 --  0.20: 6025.43 / 97595 = 0.0617
 0.21 --  0.30: 5215.15 / 75272 = 0.0693
 0.31 --  0.40: 4605.31 / 59469 = 0.0774
 0.41 --  0.50: 3392.78 / 40222 = 0.0844
 0.51 --  0.60: 3510.60 / 38036 = 0.0923
 0.61 --  0.70: 2728.45 / 27891 = 0.0978
 0.71 --  0.80: 1999.12 / 20280 = 0.0986
 0.81 --  0.90: 1956.12 / 18954 = 0.1032
 0.91 --  1.00: 1685.87 / 15973 = 0.1055
```

Table covers all Cat. 11 and higher tournaments played in 2000—2009.

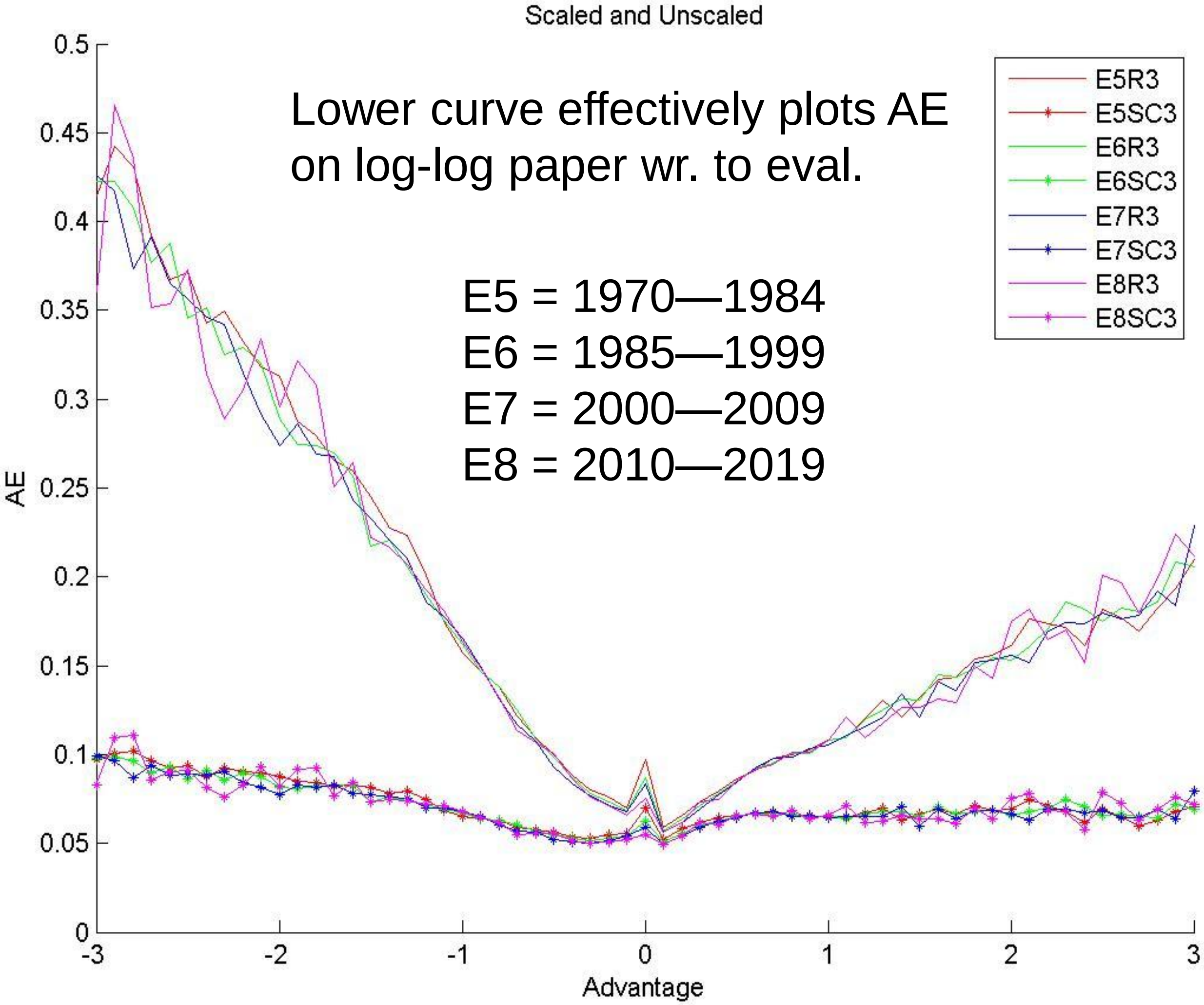
Read: In 65,310 positions the player to move was judged 21 to 30 cp behind, and made a (raw, unscaled) “error” of 7.64 cp per move.

Scripts miss some non-immediate repetitions, hence 0.00 eval set aside.

Raw figures say players make 60-90% more error when half a pawn ahead or behind than when the game is even.

Is this a “real” verdict on skill in these cases? We think not. Instead we deduce a proportionality law.

Average Error and Scaling Law



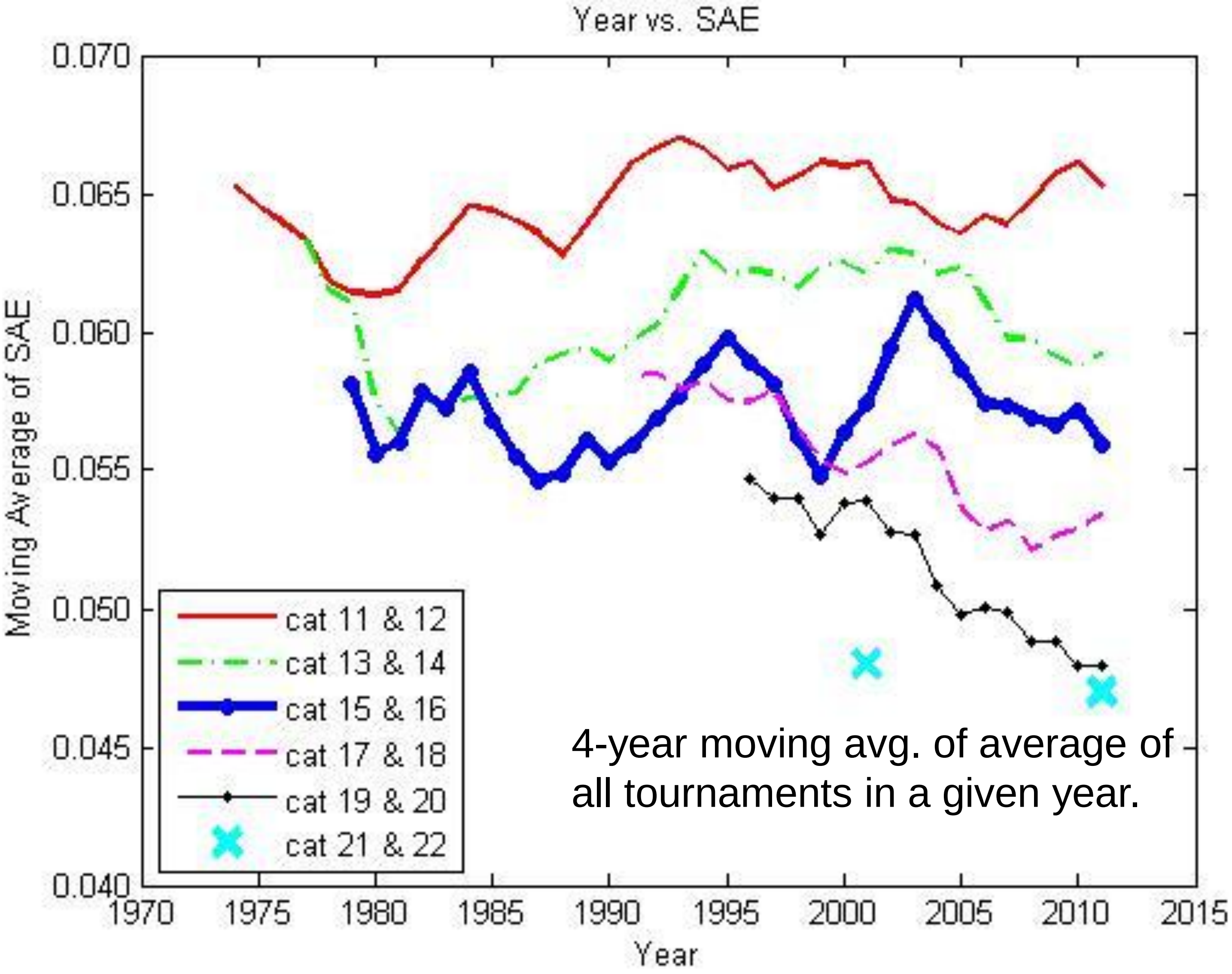
Lower curve effectively plots AE on log-log paper wr. to eval.

E5 = 1970—1984
E6 = 1985—1999
E7 = 2000—2009
E8 = 2010—2019

Scaling Law---Explication

- Marginal value ***dp*** of extra 1cp decreases as the advantage v to one side increases.
- Fractal Law: $dp = 1/(a + |v|)$. Symmetrical.
- If player makes “error” decreasing Rybka 3’s value from v to v-e, the scaled error is SAE = Integrate(v-e,v,dp) = $\ln(a+v) - \ln(a+v-e)$, doing separate pieces around 0.
- Flattest near 0 with a near 100cp, so use a=1.
- A 100cp error when v = +50cp catches fatter part of dp than when v = -50cp, so this scaling restores much of the symmetry.

Plot of SAE by Tournament Category



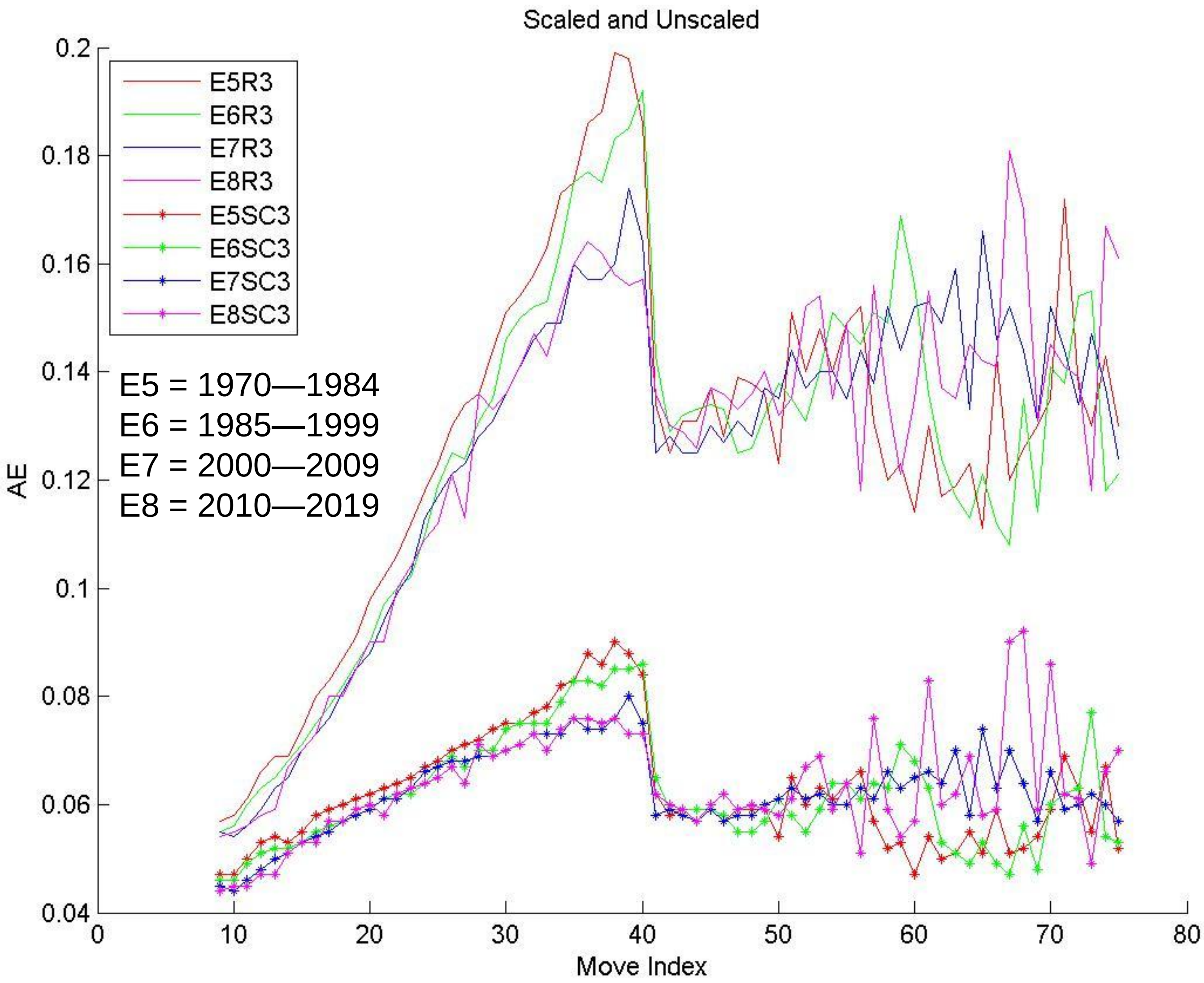
4-year moving avg. of average of all tournaments in a given year.

Plot lines would slope up if there were considerable rating inflation.

Some evidence of deflation in higher categories.

Cat 21&22 lumped 1996—2001 & 2007—2011.

Error By Move Number in Games

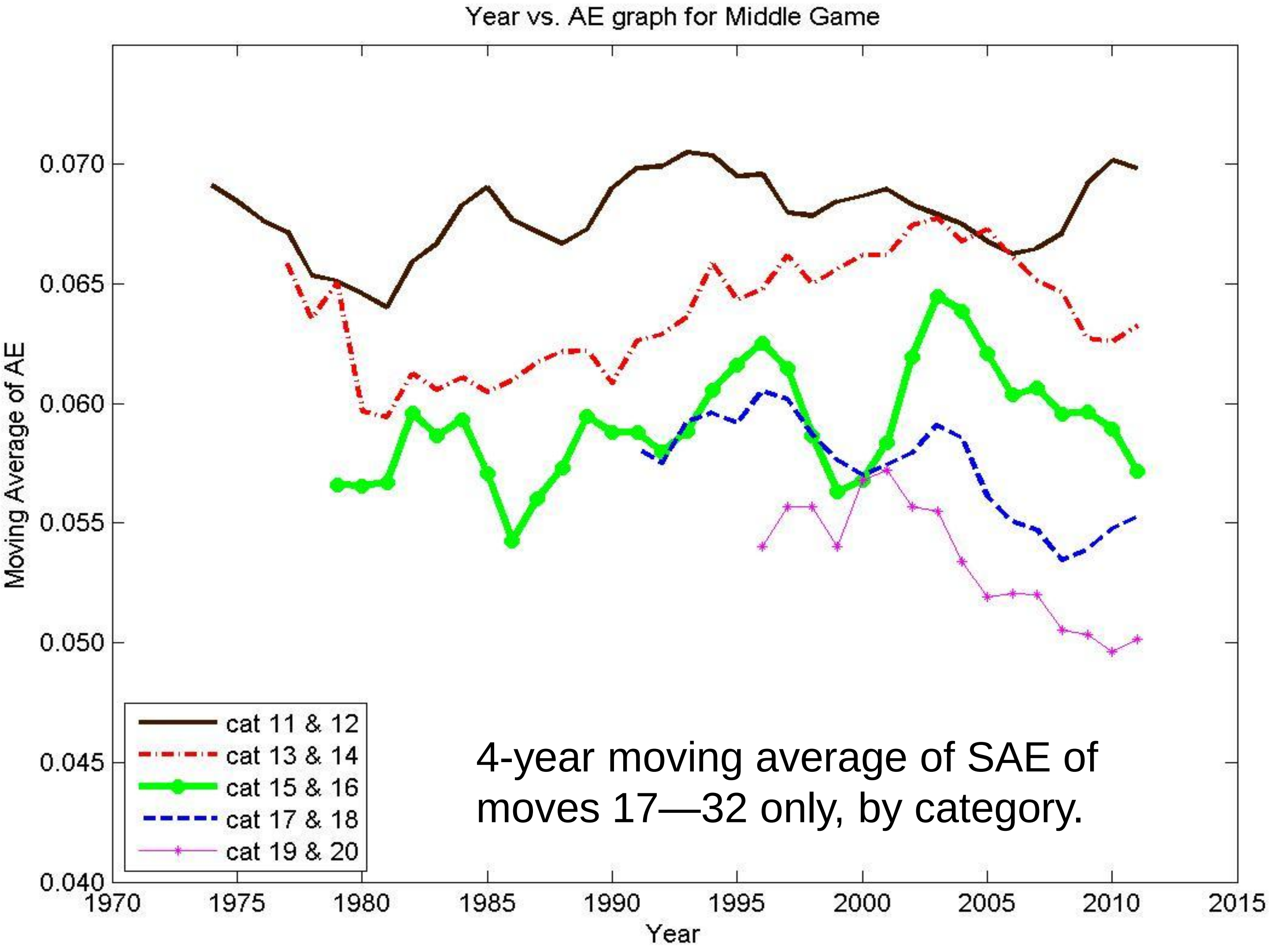


E5 = 1970—1984
E6 = 1985—1999
E7 = 2000—2009
E8 = 2010—2019

Effect of time pressure approaching Move 40 is clear.

Moves 17—32 bridge between opening theory and worst of Zeitnot.

SAE-by-Category Plot for Moves 17--32



4-year moving average of SAE of moves 17—32 only, by category.

Curves are similar to case of all moves; error itself is a little higher.

Overall no-inflation verdict thus independent of today’s greater opening theory knowledge.

Results 3: Intrinsic Perf. Ratings

- Main departure from previous work: for intrinsic (rather than relative) quality one must analyze all reasonable options.
- Vas Rajlich suggested scripting Rybka 3 to play each legal move and do Single-PV, but Rybka 3's `multipv_cp` cap innovation in Multi-PV mode became a vital timesaver.
  - Multi-PV heuristics inferior, does it matter for fixed depth?
- Transition of work from Toga II to Rybka 3 in late 2008 felt statistically "seamless"…[whereas e.g. Stockfish seems to produce 2x as many 0.00 evals.]

Skill Assessment vs. Prediction

- Skill assessment calls for the strongest available analysis, say at least 400 Elo higher.
- Prediction, however, should model players by fallible agents at their skill level.
- Best model may style every player as having “modes” ranging from “genius” to “tyro”---the not-yet-implemented “full model” envisions a wtd. linear comb. of results at different depths.
- Rybka 3 depth 13 ~= mid-2600s gives a fat central slice of it, reasonable compromise.

Fixed-Depth “Fidelity” Model

- Skill parameters sensitivity s, consistency c.
- Inputs are scaled differences δ_i for each legal move m_i in a given position. Engine’s first move is m_0, so $\delta_0 = 0$.
- Primary outputs are projected probabilities $\boldsymbol{p_i}$ for each move m_i.
- Related by

$$\boxed{\frac{\ln(1/p_0)}{\ln(1/p_i)} = \exp\left(\left(\frac{\delta_i}{s}\right)^c\right)}$$

Why this eqn? Good question! It works.

- Parameters s,c fitted to Elo scale using games between players within 10 pts. of a century mark 2700, 2600, 2500,…

Applying the Model

- [Regan-Haworth, AAAI 2011]: obtains similar *s*,*c* values when fitting to data in 2006—2009, 1991—1994, 1976—1979.
  – Evidence against inflation between those times.
- **This paper**: direct translation from *s*,*c* to Elo.
- From *s*,*c* derive probabilities $\boldsymbol{p_{it}}$ for all turns *t*.
- Over reference turns derive projected (S)AE:

$$AE_e = \frac{1}{N}\sum_{t=1}^{N}\sum_{i} p_{it}\delta_{it}$$

- Fit AE_e to rating: **IPR = 3571 – 15,413*AE_e**.

Training Set Results

2006—2009 linear interpolation

Elo	*s*	*c*	IPR
2700±10	.078	.503	2690
2600±10	.092	.523	2611
2500±10	.092	.491	2510
2400±10	.098	.483	2422
2300±10	.108	.475	2293
2200±10	.123	.490	2213

(Elos <= 2100 not used in interpolation)

1991—1994 derived IPR values

Elo	*s*	*c*	IPR
2700±10	.079	.487	2630
2600±10	.092	.533	2639
2500±10	.098	.500	2482
2400±10	.101	.484	2396
2300±10	.116	.480	2237
2200±10	.122	.477	2169

1976—1979 derived IPR values

2600±10	.094	.543	2647
2500±10	.094	.512	2559
2400±10	.099	.479	2397
2300±10	.121	.502	2277

Inflation would show as IPR > Elo in tables at right. Pretty much none.

Some Recent Tournaments

Event	cat	Elo	IPR	Diff	Event	cat	Elo	IPR	Diff
Linares 1993	18	2676	2522	-154	Corus 2007	19	2717	2763	+46
Linares 1994	18	2685	2517	-168	Mexico 2007	21	2751	2708	-43
Dortmund 1995	17	2657	2680	+23	Sofia 2007	19	2725	2576	-149
Dortmund 1996	18	2676	2593	-83	Sofia 2008	20	2737	2690	-47
Dortmund 1997	18	2699	2639	-60	Sofia 2009	21	2754	2703	-51
Dortmund 1998	18	2699	2655	-44	Nanjing 2010	21	2766	2748	-18
Dortmund 1999	19	2705	2749	+44	Shanghai 2010	21	2759	2829	+70
Sarajevo 1999	19	2703	2722	+19	Bilbao 2010	22	2789	2904	+115
San Luis 2005	20	2738	2657	-81	Moscow 2010	21	2757	2690	-67
Corus 2006	19	2715	2736	+21	London 2010	20	2725	2668	-57
Sofia 2006	20	2744	2744	0	**Averages**	**19**	**2722**	**2690**	**-32.6**

IPRs are reasonable; half of shortfall is from Linares 1993-94.

No support for inflation hypothesis here either.

Results 4. Within a Big Tournament

- Canadian Open, July 9-17, 2011, 9-rd. Swiss.
- 149 players (152 orig.), 115 with FIDE ratings.
- 647 games played; 623 available & analysed.

Whole event	CanR	TPR	IPR		Restrict	CanR	FIDE	IPR
Average	2144	2142	**2117**		to 115	2211	2139	**2203**
St. Deviation	258	261	**379**		FIDE-	229	220	**345**
Wtd. by games	2156	2154	**2134**		rated	2221	2147	**2219**
Wtd. by moves	2173	2172	**2161**		players:	2236	2161	**2242**

1. IPRs are reasonable overall but individually more volatile than TPRs.
2. IPRs track Canadian ratings better than FIDE, though trained on FIDE.
3. Hence some evidence that FIDE ratings of Canadian players are deflated.

Conclusions and Future Work

- Disparate kinds of evidence counter "conventional wisdom" of substantial rating inflation.
- AE stat effective on largest scales.
- IPR's from Multi-PV analysis effective on scale of individual (players in) events.
- To-do list (would like analysis helpers):
  1. Improve scripting and data format. Propose AIF: "Analysis Interchange Format" extending PGN and EPD. (Compare Fritz 13 "Let's Check")
  2. Implement "full model" weighting over depths.
  3. Analyze distributions of/within tournaments.
  4. Apply to other tournament kinds, issues, games.

Special Thanks, and Requests

- Thanks most to Arena GUI programmers for full analysis scripting. www.playwitharena.com
- Toga II and Rybka programmers gave help.
- UB CSE and Univ. de Montreal provided support.
- Tamal Biswas collated data and created graphs.
- Hugh Brodie, David Cohen: Can. Open games.
  - Can engines be set to record 0.00 at top level only when position appears for 3rd time?
  - Erroneous gamescores are a major problem! See my 30+ proposed corrections at www.chessgames.com. Multi-PV training sets cleaned fully, ~1% bad game rate.
  - UCI clear-hash without `ucinewgame`, like Crafty does?
  - Other engines implement Multi-PV cap feature. More?