Survival Analysis of NHL Prospect Timelines

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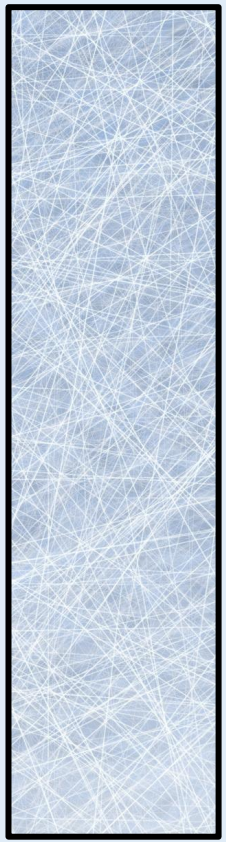
RIT Hockey Analytics Conference 2017



What do we know about hockey?

- Well, we know some stuff about what players do after they make it to the NHL.
- We know a bit about the variables that affect teams' draft decisions.
- We know almost nothing about the factors that drive what happens in between.

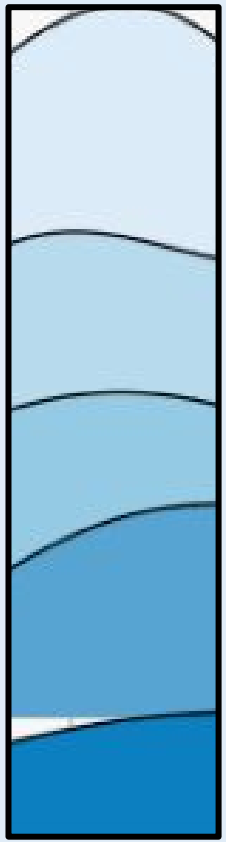
Draft → ¯_(ツ)_/¯ → NHL

What's the existing literature?

- I couldn't find much, so I wrote an article for The Athletic Philly.
- I tried to answer 2 questions:

  How long does it take for different types of prospects to make it to the NHL?

  How does this prospect timeline relate to the **value** they eventually create for their NHL teams?

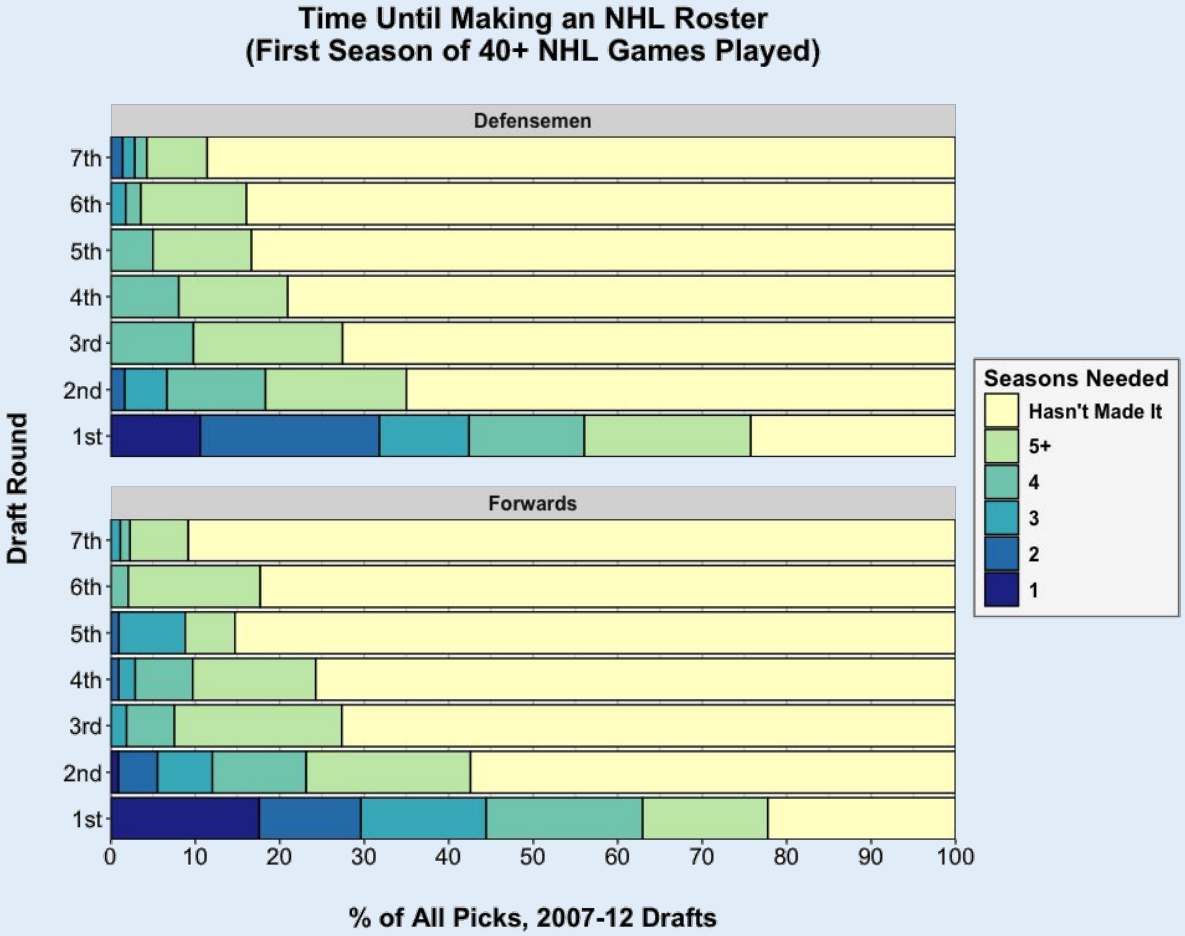


My Original Methodology

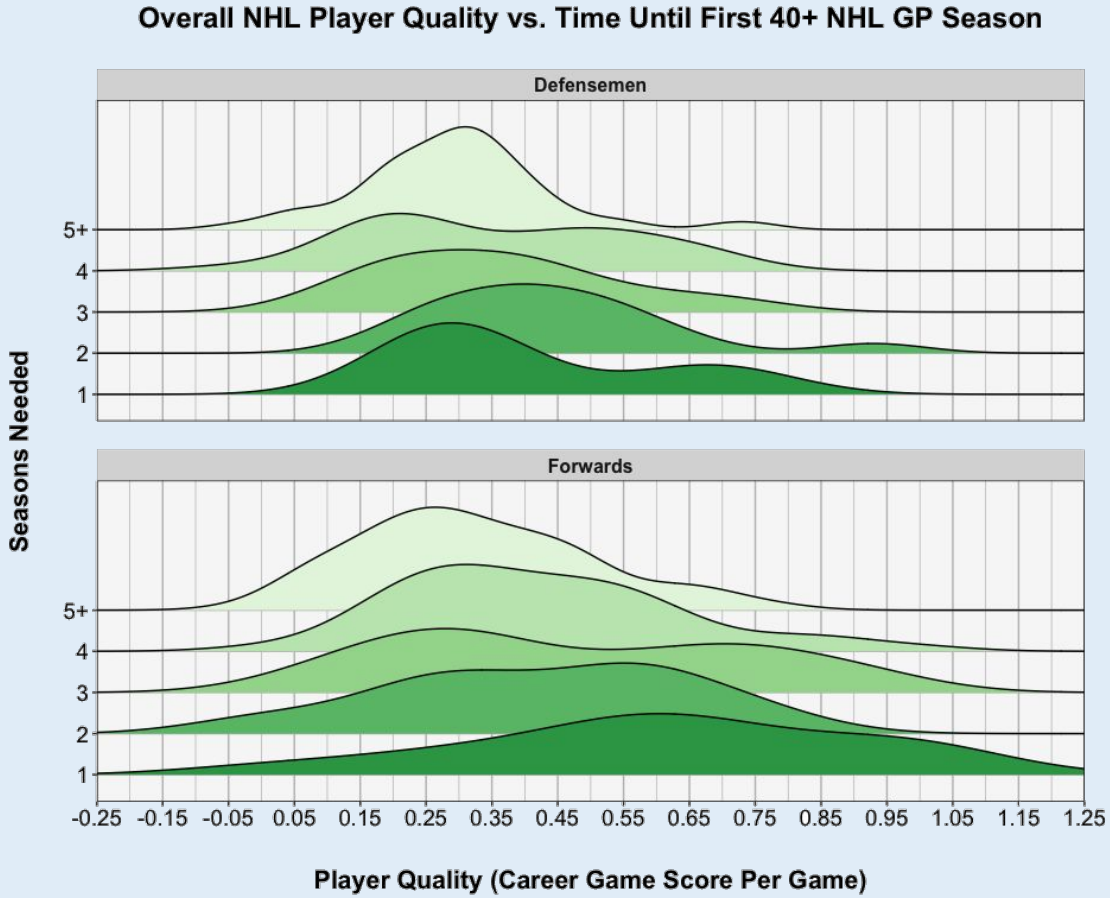
- Classify “making an NHL roster” as 40+ NHL games played in a single season*.
- Look at the distribution of prospect timelines stratified by draft round and position for the ‘07-12 drafts.
- Test for a statistically significant relationship between time until making a roster and NHL impact.

* All of these analyses are looking exclusively at skaters.

Stratification of Draft Round and Position



NHL Value Distributions by Timeline

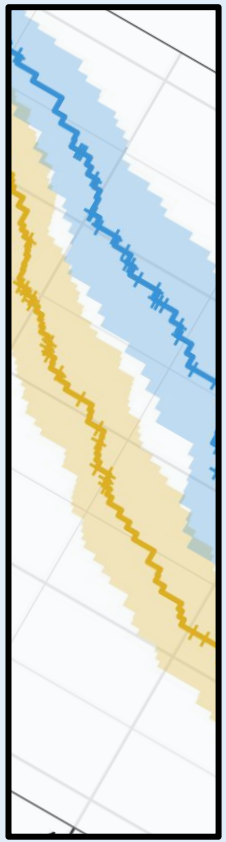


Game Score courtesy of Dom Luszczyszyn

What are some problems with my approach?

A month ago,
I thought it was a
pretty good article.

- *Limiting the Data*: I excluded recently drafted players and binned longer timelines.
- *Loss of Granularity*: We don't know when, within a season, these prospects played.
- *Arbitrary Cutoffs*: 40 games? Who cares about 40 games?
- *Undefined Effects*: We know that variables like position and draft round have effects, but what are they?



Survival Analysis

- Often used to answer questions in fields such as biostatistics and marketing.

  How long do patients live after treatment? How long do customers go before trying our products?

  How long do prospects develop before making the NHL?

- Good for dealing with right-censored data, like most recent draftees.
- Can estimate the effects of covariates like draft position and size.
- Usually a tradeoff between imposing very few assumptions vs. ease of interpreting and predicting outcomes.

What does the data look like?

I decided to evaluate time until 1st, 10th, 40th, and 80th career games.

1st Game Benchmark:

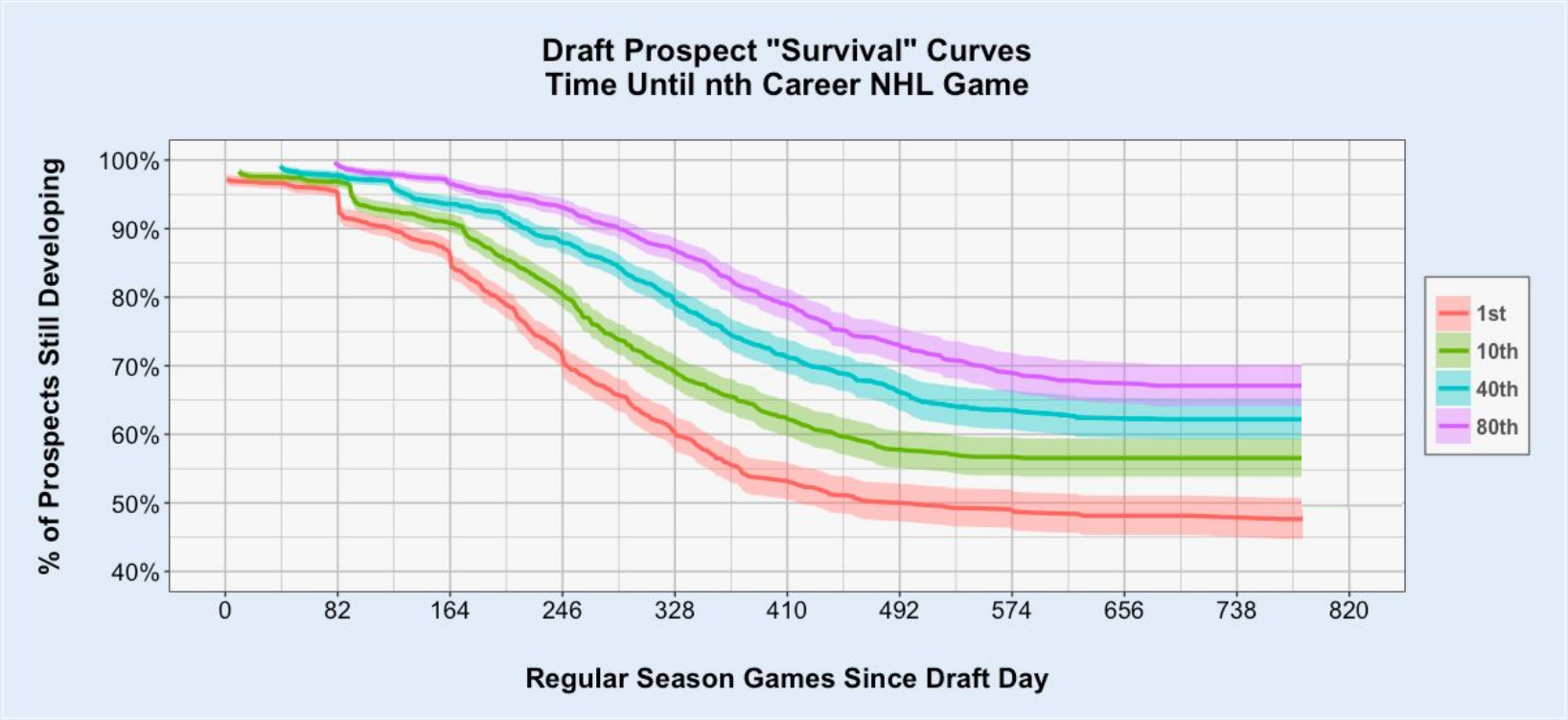
time	status	year	round	overall	team	player
1	1	2015	1	1	EDM	CONNOR.MCDAVID
1	1	2015	1	2	BUF	JACK.EICHEL
84	1	2015	1	3	ARI	DYLAN.STROME
83	1	2015	1	4	TOR	MITCHELL.MARNER
1	1	2015	1	5	CAR	NOAH.HANIFIN
82	1	2015	1	6	NJD	PAVEL.ZACHA
83	1	2015	1	7	PHI	IVAN.PROVOROV

80th Game Benchmark:

time	status	year	round	overall	team	player
117	1	2015	1	1	EDM	CONNOR.MCDAVID
81	1	2015	1	2	BUF	JACK.EICHEL
164	0	2015	1	3	ARI	DYLAN.STROME
164	0	2015	1	4	TOR	MITCHELL.MARNER
83	1	2015	1	5	CAR	NOAH.HANIFIN
164	0	2015	1	6	NJD	PAVEL.ZACHA
162	1	2015	1	7	PHI	IVAN.PROVOROV

Time: regular season games since draft day

Status: 1 if entry into the NHL was observed at that time,
0 if it hasn't happened by the end of the 2016-17 regular season

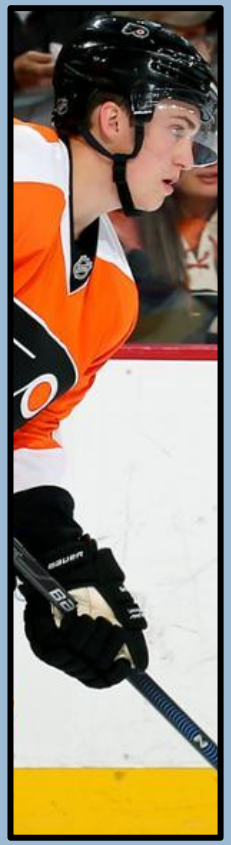


Kaplan-Meier Curves: All Skaters

Cox Proportional Hazards Model

In 20 seconds.

- Semi-parametric.
- Can estimate the multiplicative effects of covariates.
- (Relative) ease of interpretation.
- Using a baseline hazard estimator (Breslow), we can compute “survival” curves for individual players.



Before We Discuss Covariates...

Remember that the process of prospect entry into the NHL is governed by two distinct features:

- Player quality + performance at lower levels.
- Team needs + preferences.

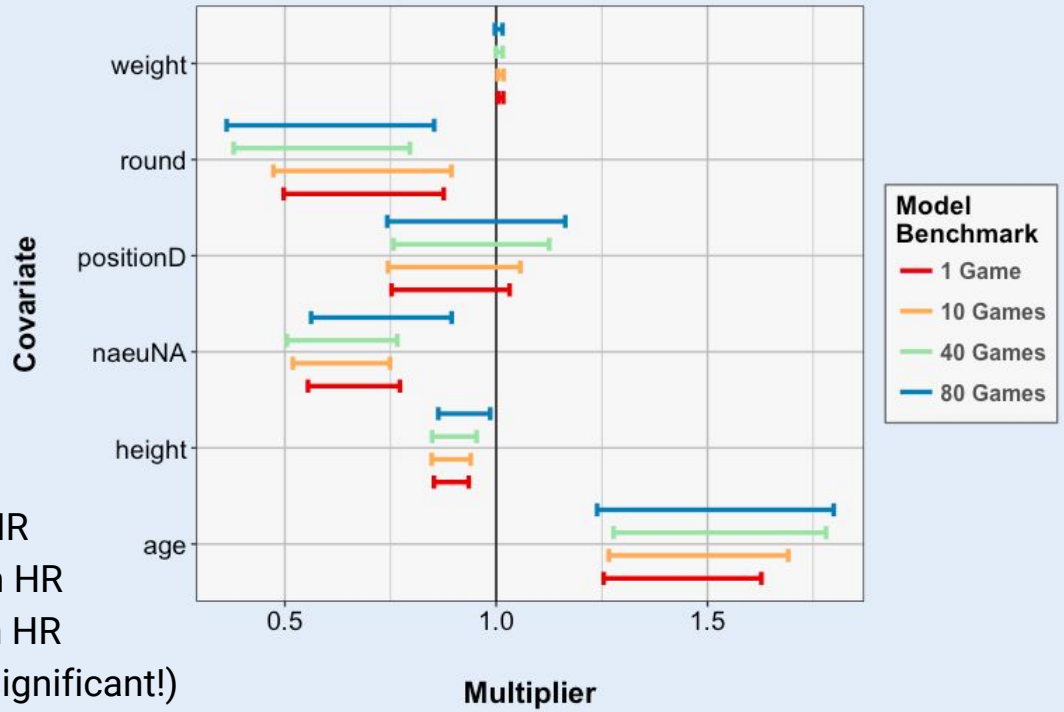
The answer to the question "*Why is this covariate value associated with prospects making it to the NHL earlier?*" can really be a mix of two answers:

- The variable is associated with better quality players.
- The variable is associated with players that teams like and/or feel that they particularly need.

Covariate Effects

hazard rate *(HR) =*
P(entering the league at time t
given that you haven't by t-1)

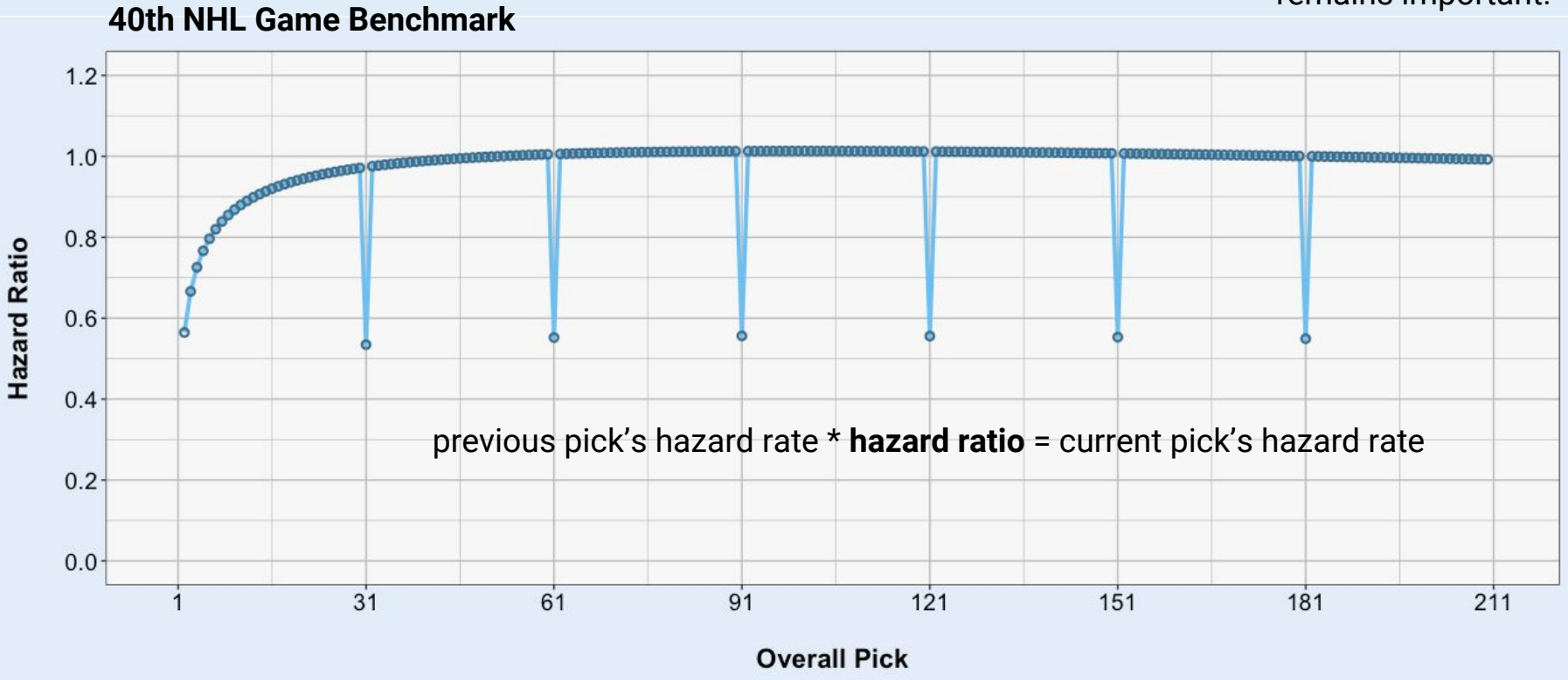
- + 1 pound heavier = ~1% increase in HR
- + 1 draft round = ~45% decrease in HR
- defensemen = ~10% decrease in HR
  (not statistically significant!)
- North American = ~35% decrease in HR
- + 1 inch taller = ~10% decrease in HR
- + 1 year older = ~47% increase in HR

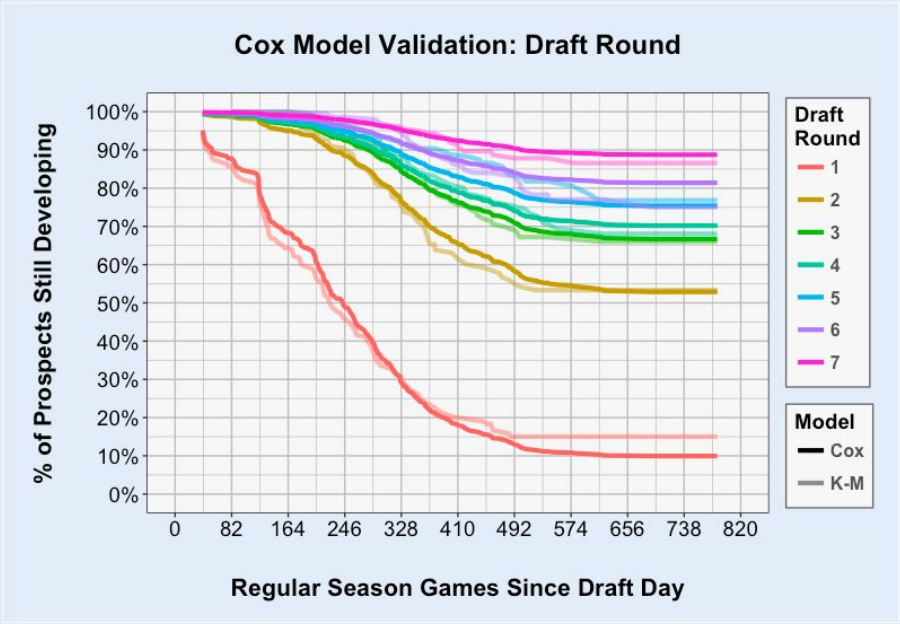


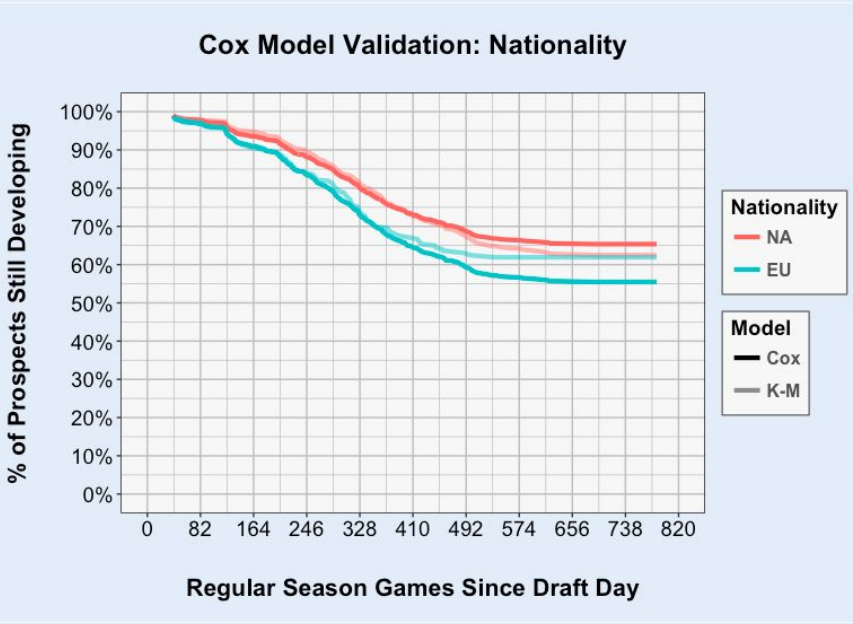
(also known as **hazard ratio**)

Effects of Draft Round + Pick

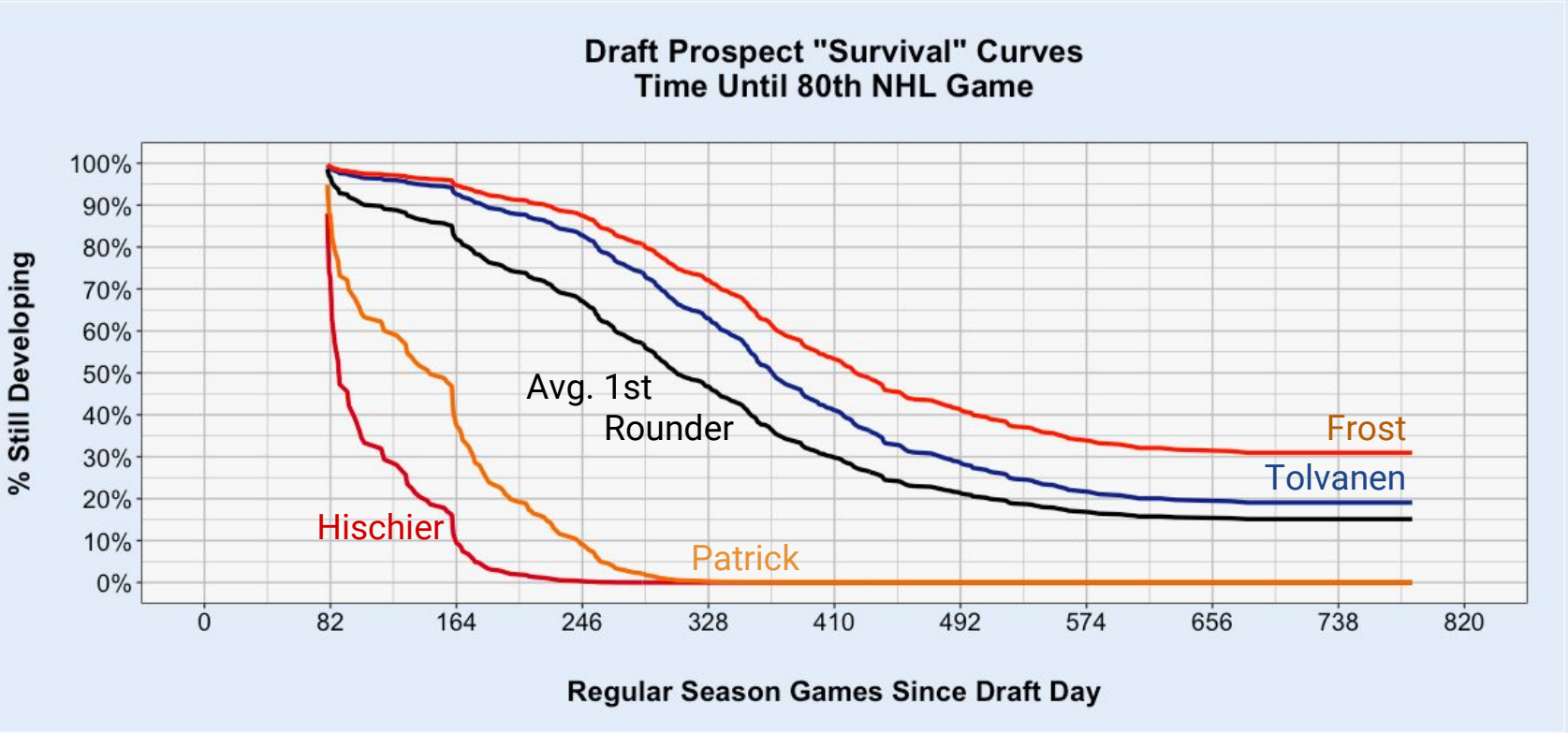
The effect between picks dissipates quickly, but the effect between rounds remains important!







Graphical Validation of Cox Model: 40th NHL Game Benchmark

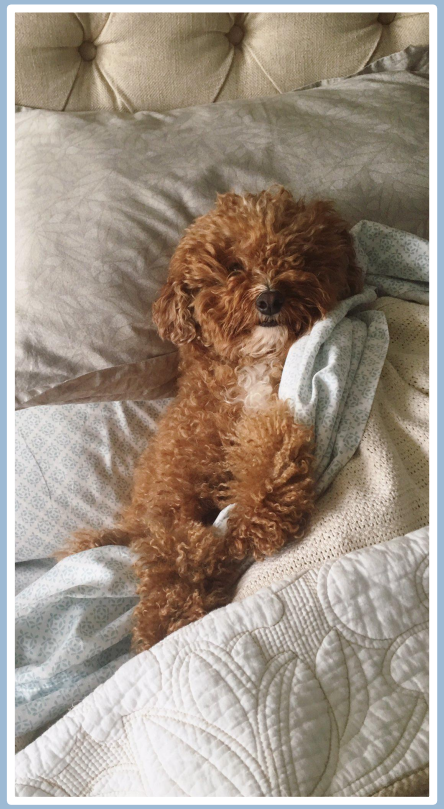


Prospect Projections: 2017 Draft

Additional Questions

For the future.

- Should we include additional covariates (ex. junior point production)?
- How do these NHL timeline estimates relate to eventual NHL performance?
- After a prospect makes a roster, is staying in the NHL a time-varying Markov chain?
- Which teams over- and under-season their prospects to a significant degree?



Thank you!

To all of you for listening, but in particular, to:

- Prof. Shane Jensen (Wharton Statistics) and Elliot Oblander (Wharton) for the analytical advice.
- Manny Perry (corsica.hockey) for providing me with NHL game data.

If you liked this presentation, I'm @nnstats on Twitter. If not, I'm @charlieo_conn.

Appendix: Cox PH Model Output

1st Game Benchmark

	coef	exp(coef)	se(coef)	z	Pr(>|z|)	
height	-1.131e-01	8.930e-01	2.348e-02	-4.818	1.45e-06	***
weight	1.032e-02	1.010e+00	3.124e-03	3.303	0.000958	***
I(overall^(0.5))	-1.295e+00	2.740e-01	1.235e-01	-10.483	< 2e-16	***
overall	9.535e-02	1.100e+00	1.457e-02	6.544	5.99e-11	***
I(overall^2)	-1.314e-04	9.999e-01	2.901e-05	-4.531	5.86e-06	***
positionD	-1.267e-01	8.810e-01	8.053e-02	-1.573	0.115764	
age	3.568e-01	1.429e+00	6.643e-02	5.371	7.83e-08	***
naeuNA	-4.240e-01	6.544e-01	8.437e-02	-5.026	5.02e-07	***
round	-4.154e-01	6.601e-01	1.445e-01	-2.875	0.004037	**

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	exp(coef)	exp(-coef)	lower .95	upper .95
height	0.8930	1.1198	0.8529	0.9351
weight	1.0104	0.9897	1.0042	1.0166
I(overall^(0.5))	0.2740	3.6493	0.2151	0.3491
overall	1.1000	0.9091	1.0691	1.1319
I(overall^2)	0.9999	1.0001	0.9998	0.9999
positionD	0.8810	1.1350	0.7524	1.0317
age	1.4287	0.6999	1.2543	1.6274
naeuNA	0.6544	1.5281	0.5547	0.7721
round	0.6601	1.5150	0.4973	0.8761

10th Game Benchmark

	coef	exp(coef)	se(coef)	z	Pr(>|z|)	
height	-1.139e-01	8.923e-01	2.644e-02	-4.309	1.64e-05	***
weight	1.017e-02	1.010e+00	3.527e-03	2.883	0.00394	**
I(overall^(0.5))	-1.551e+00	2.120e-01	1.372e-01	-11.306	< 2e-16	***
overall	1.215e-01	1.129e+00	1.636e-02	7.423	1.14e-13	***
I(overall^2)	-1.869e-04	9.998e-01	3.284e-05	-5.691	1.26e-08	***
positionD	-1.200e-01	8.869e-01	8.964e-02	-1.339	0.18052	
age	3.808e-01	1.463e+00	7.382e-02	5.158	2.50e-07	***
naeuNA	-4.728e-01	6.232e-01	9.363e-02	-5.050	4.41e-07	***
round	-4.306e-01	6.501e-01	1.626e-01	-2.649	0.00808	**

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	exp(coef)	exp(-coef)	lower .95	upper .95
height	0.8923	1.1207	0.8473	0.9398
weight	1.0102	0.9899	1.0033	1.0172
I(overall^(0.5))	0.2120	4.7173	0.1620	0.2774
overall	1.1292	0.8856	1.0935	1.1660
I(overall^2)	0.9998	1.0002	0.9997	0.9999
positionD	0.8869	1.1275	0.7440	1.0572
age	1.4634	0.6833	1.2663	1.6912
naeuNA	0.6232	1.6045	0.5187	0.7488
round	0.6501	1.5382	0.4727	0.8941

40th Game Benchmark

	coef	exp(coef)	se(coef)	z	Pr(>|z|)	
height	-0.1060682	0.8993633	0.0299011	-3.547	0.000389	***
weight	0.0074141	1.0074416	0.0040374	1.836	0.066308	.
I(overall^(0.5))	-1.7211444	0.1788614	0.1519049	-11.330	< 2e-16	***
overall	0.1420136	1.1525923	0.0186304	7.623	2.49e-14	***
I(overall^2)	-0.0002150	0.9997850	0.0000374	-5.749	8.98e-09	***
positionD	-0.0801400	0.9229871	0.1011928	-0.792	0.428388	
age	0.4109134	1.5081947	0.0846442	4.855	1.21e-06	***
naeuNA	-0.4749296	0.6219288	0.1061682	-4.473	7.70e-06	***
round	-0.5993628	0.5491615	0.1894869	-3.163	0.001561	**

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	exp(coef)	exp(-coef)	lower .95	upper .95
height	0.8994	1.1119	0.8482	0.9536
weight	1.0074	0.9926	0.9995	1.0154
I(overall^(0.5))	0.1789	5.5909	0.1328	0.2409
overall	1.1526	0.8676	1.1113	1.1955
I(overall^2)	0.9998	1.0002	0.9997	0.9999
positionD	0.9230	1.0834	0.7569	1.1255
age	1.5082	0.6630	1.2776	1.7804
naeuNA	0.6219	1.6079	0.5051	0.7658
round	0.5492	1.8210	0.3788	0.7961

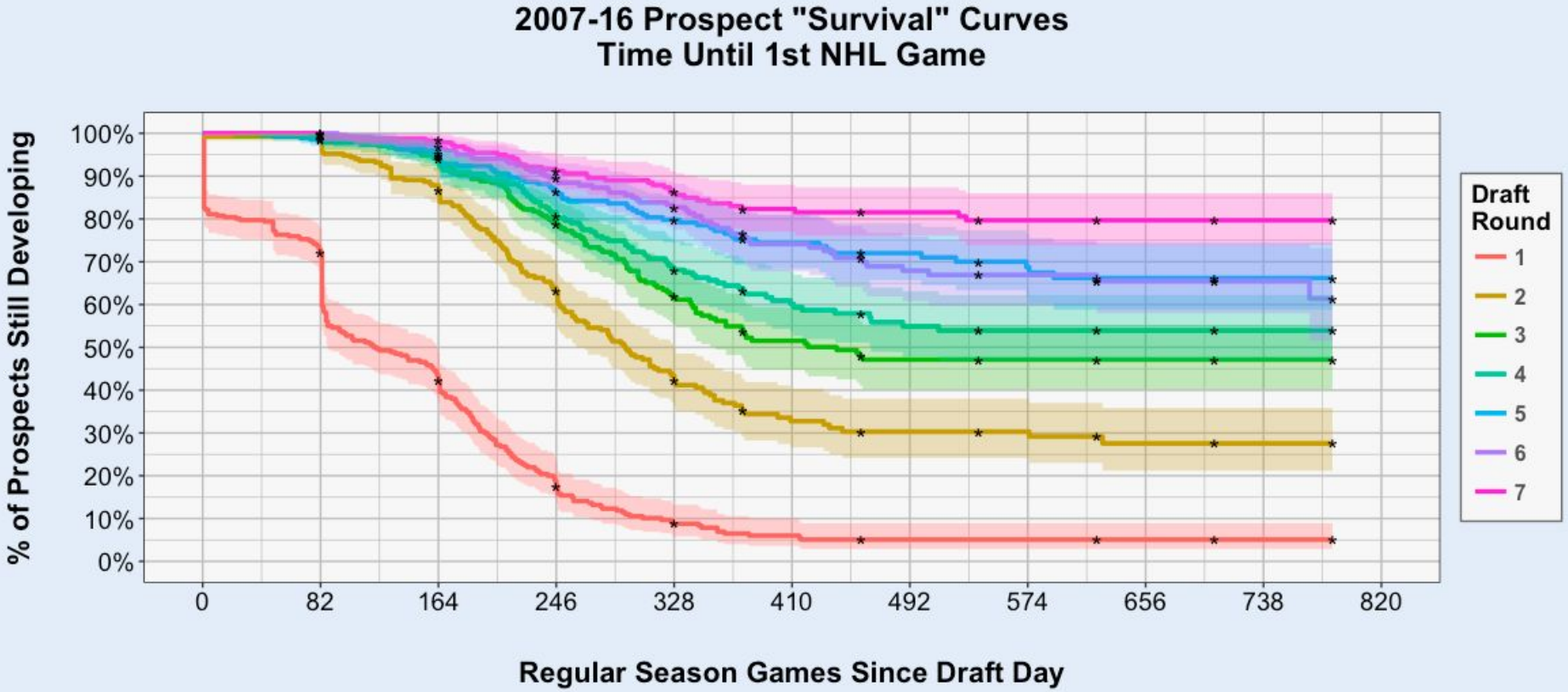
80th Game Benchmark

	coef	exp(coef)	se(coef)	z	Pr(>|z|)	
height	-8.069e-02	9.225e-01	3.390e-02	-2.380	0.01732	*
weight	5.765e-03	1.006e+00	4.612e-03	1.250	0.21134	
I(overall^(0.5))	-1.713e+00	1.803e-01	1.685e-01	-10.167	< 2e-16	***
overall	1.433e-01	1.154e+00	2.125e-02	6.740	1.58e-11	***
I(overall^2)	-2.241e-04	9.998e-01	4.288e-05	-5.226	1.73e-07	***
positionD	-7.355e-02	9.291e-01	1.147e-01	-0.641	0.52152	
age	4.006e-01	1.493e+00	9.514e-02	4.211	2.55e-05	***
naeuNA	-3.439e-01	7.090e-01	1.186e-01	-2.900	0.00373	**
round	-5.871e-01	5.559e-01	2.186e-01	-2.686	0.00724	**

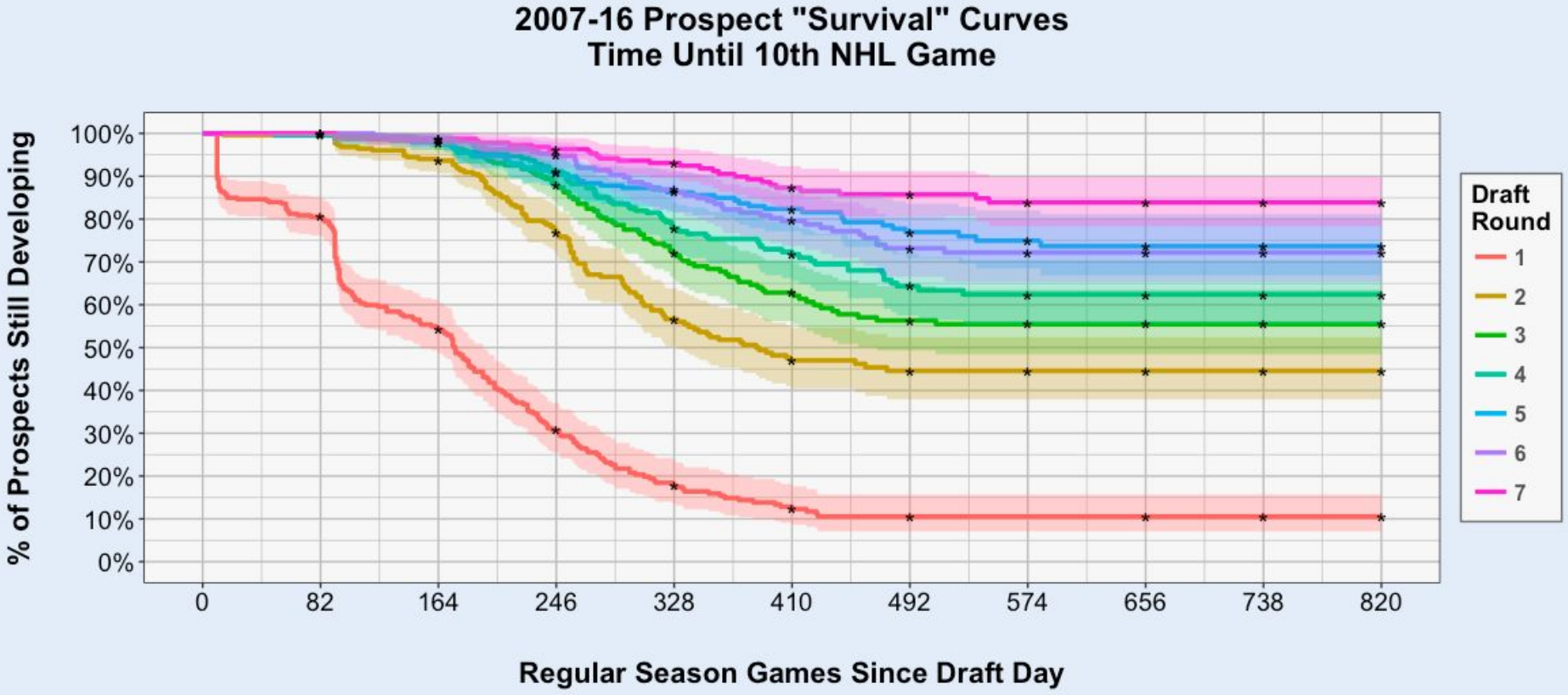
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

	exp(coef)	exp(-coef)	lower .95	upper .95
height	0.9225	1.0840	0.8632	0.9859
weight	1.0058	0.9943	0.9967	1.0149
I(overall^(0.5))	0.1803	5.5468	0.1296	0.2508
overall	1.1540	0.8665	1.1069	1.2031
I(overall^2)	0.9998	1.0002	0.9997	0.9999
positionD	0.9291	1.0763	0.7420	1.1634
age	1.4927	0.6699	1.2388	1.7987
naeuNA	0.7090	1.4105	0.5620	0.8945
round	0.5559	1.7988	0.3622	0.8533

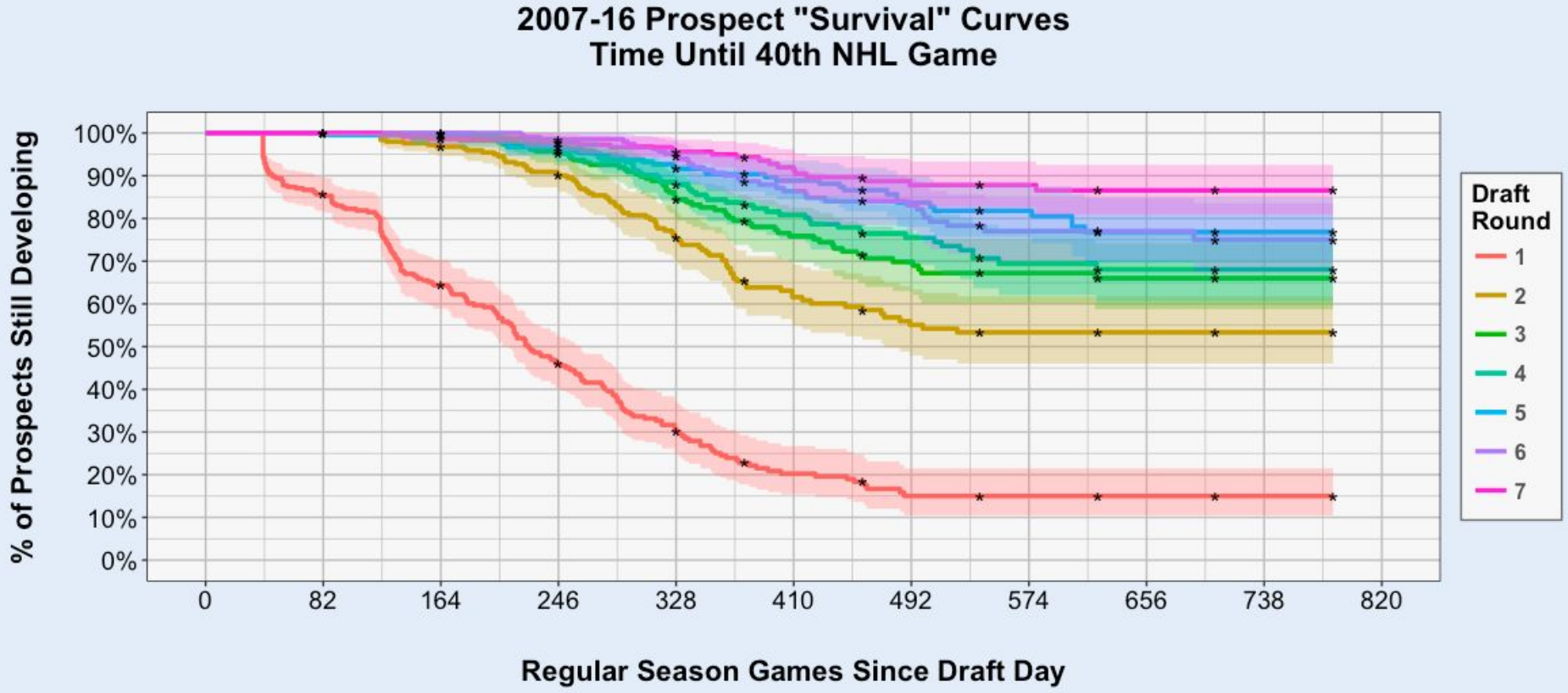
Appendix: Just a Ton of Kaplan-Meier Curves



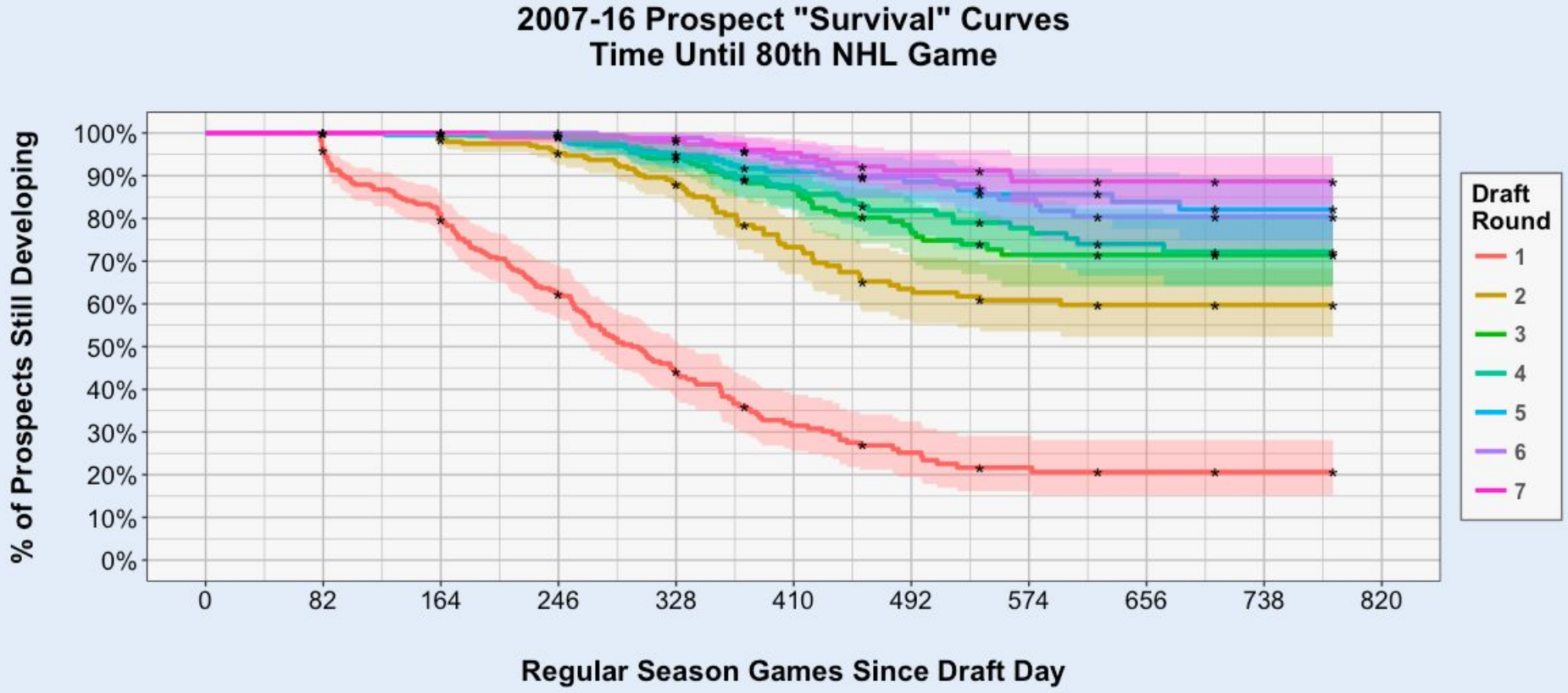
Draft Round: 10 Games



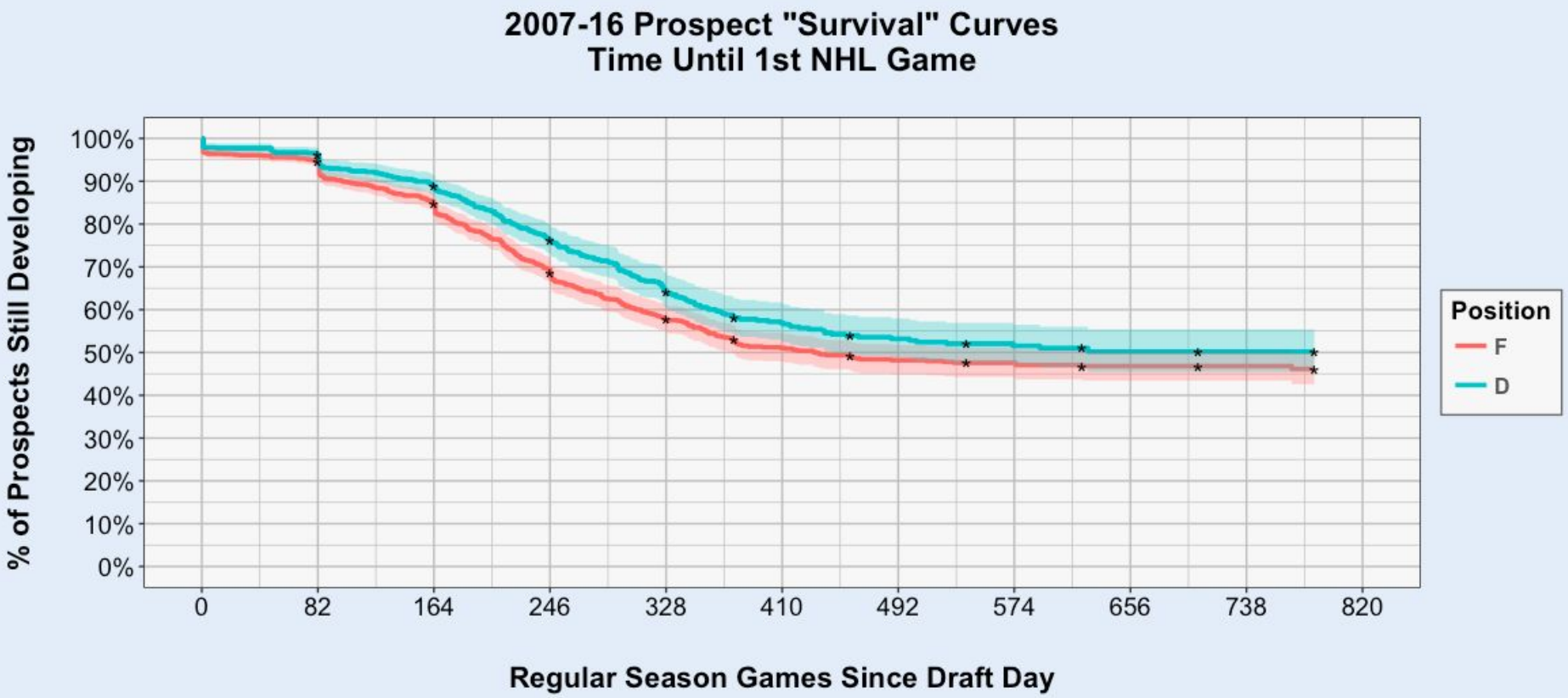
Draft Round: 40 Games



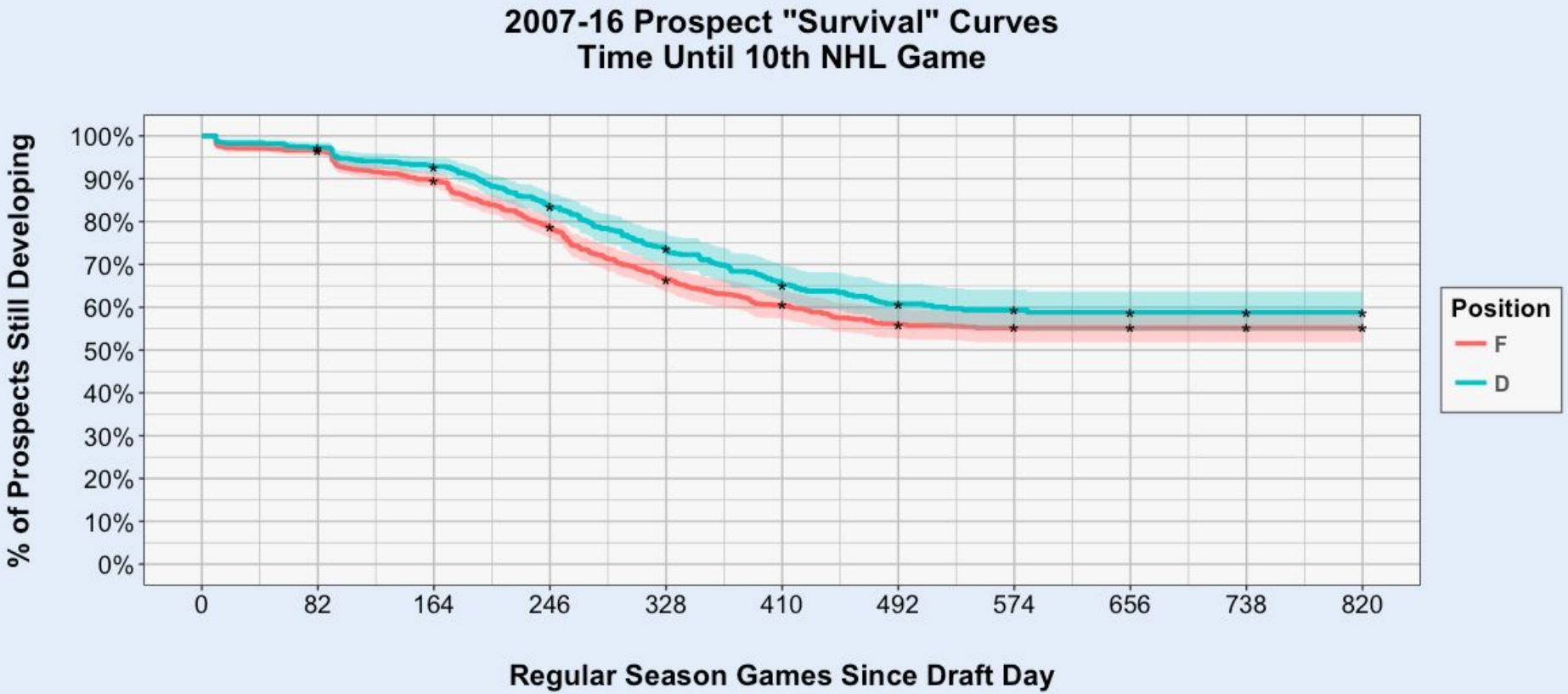
Draft Round: 80 Games



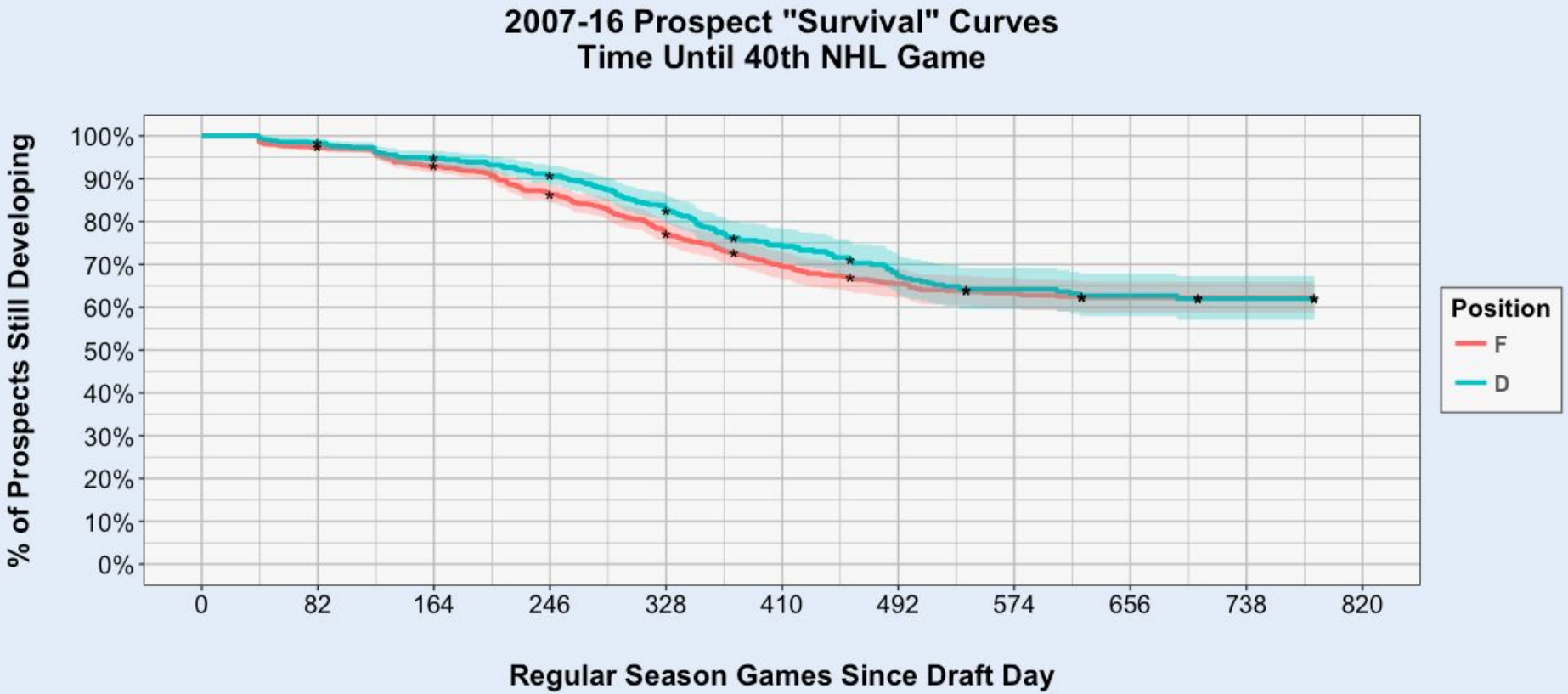
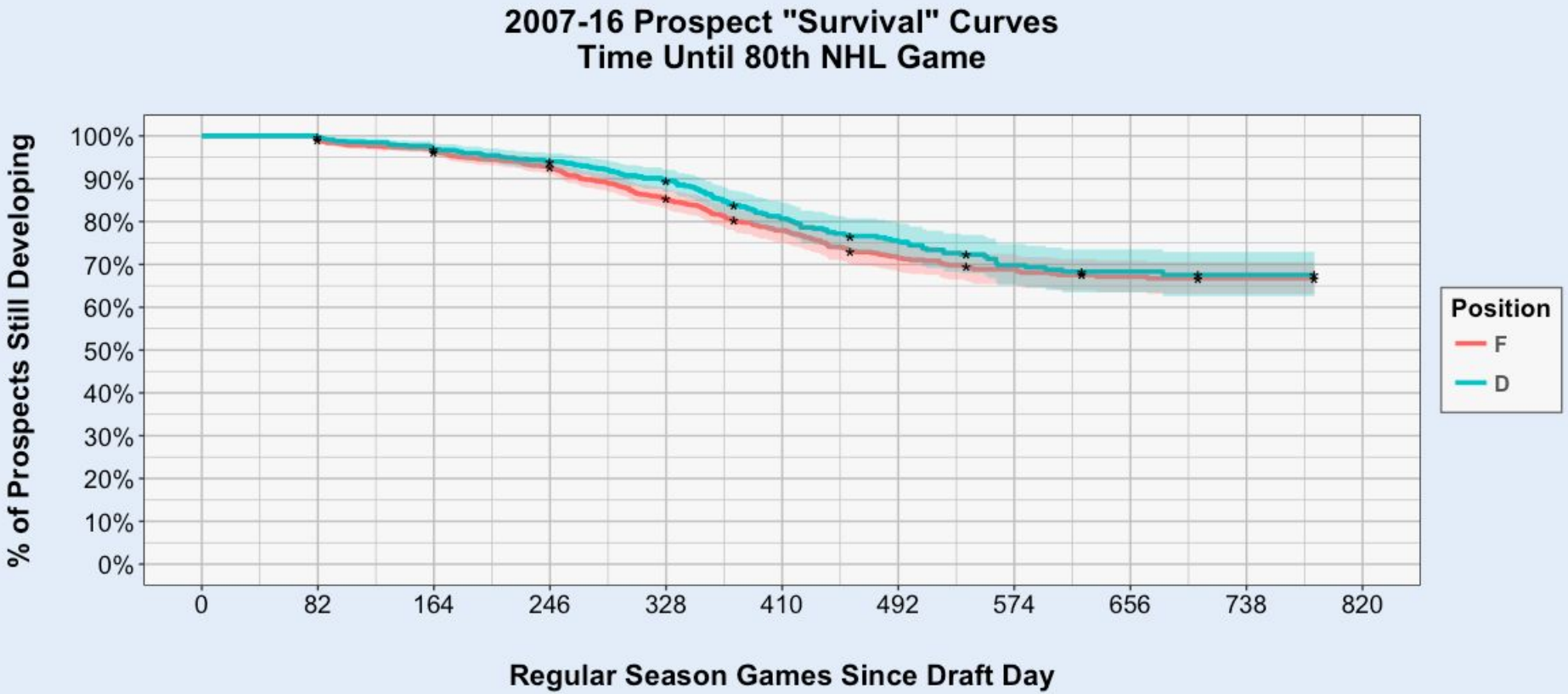
Position: 1 Game



Position: 10 Games



Position: 40 Games



Position: 80 Games