Modeling International Figure Skating Scores

Statistics 98

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Intro to the Research Topic

My final project seeks to analyze figure skating competition data from the past Olympic cycle in order to predict the 2022 World Championship results and assess potential judging bias.

Research Question

- What are the most significant predictors that determine a skater's total score and rank, and how can we use this to predict the 2022 World Championships?
- Do skaters receive a home-town advantage in scores when competing in their home country?

Data Collection Process

I scraped data from the past Olympic cycle using the `rvest` package from skatingscores.com, which uploads scoring protocols from all international and major domestic competitions under the IJS (International Judging System).

- I chose skaters who earned the top 15 free skate scores at the past two senior world championships (2022 and 2021).
- Selected skaters who competed at the world championships because oftentimes large countries like Russia will have several top scoring skaters, but each country can only send a maximum of three skaters to the world championships.
- Due to the volatile nature of the sport and short-lived seasons of skaters, I chose skaters who have been performing well in the past two years.

Due to the Russia-Ukraine conflict in recent months, the International Skating Union banned Russian athletes from participating in any international figure skating competitions on or after March 1, 2022, including the 2022 World Championships.

Rank	Name	NOC Code	Starting Number	Total Segment Score	Total Element Score	Total Program Component Score (factored)	Total Deductions
1	CHEN Nathan	USA	28	113.97	65.98	47.99	0.00

#	Executed Elements	Info	Base Value	GOE	J1	J2	J3	J4	J5	J6	J7	J8	J9	Ref.	Scores of Panel
1	4F		11.00	4.40	4	4	5	4	4	4	4	4	4		15.40
2	3A		8.00	2.29	3	3	3	3	4	2	2	2	4		10.29
3	CCSp4		3.20	1.05	4	4	3	4	3	3	3	3	3		4.25
4	4Lz+3T		17.27 x	3.94	4	4	4	3	4	2	2	3	4		21.21
5	StSq4		3.90	1.95	5	5	5	5	5	5	4	5	5		5.85
6	FSSp4		3.00	1.03	3	4	4	3	4	3	3	3	4		4.03
7	CCoSp4		3.50	1.45	4	4	4	5	4	4	4	5	4		4.95
			49.87												**65.98**

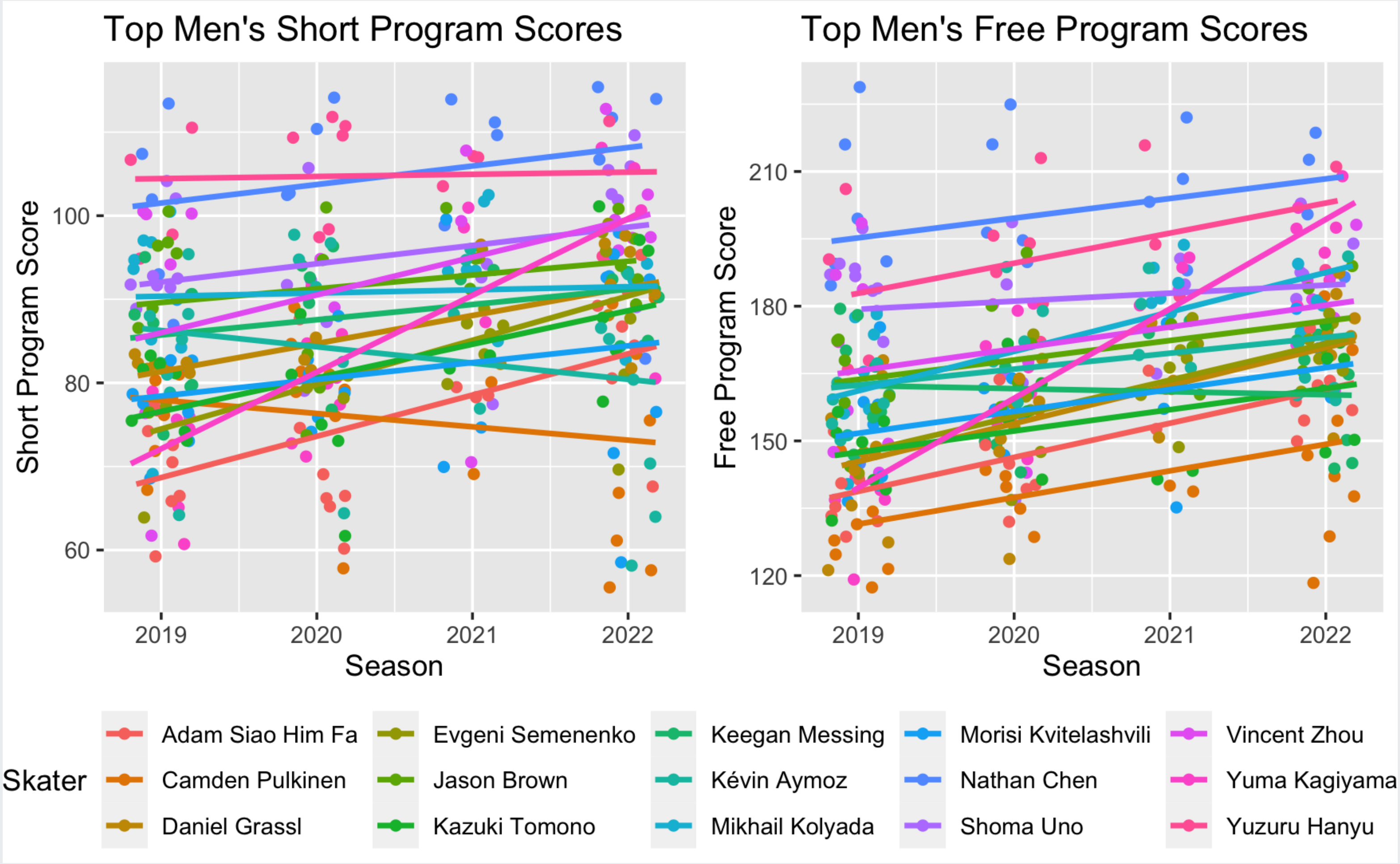
Program Components	Factor	J1	J2	J3	J4	J5	J6	J7	J8	J9	Scores of Panel
Skating Skills	1.00	9.75	9.25	9.50	9.75	9.50	9.75	9.50	9.50	9.50	9.57
Transitions	1.00	9.75	9.25	9.25	9.50	9.50	9.50	9.25	9.00	9.50	9.39
Performance	1.00	10.00	9.50	9.75	10.00	9.50	9.75	9.50	9.50	10.00	9.71
Composition	1.00	9.75	9.50	10.00	9.75	9.75	9.75	9.25	9.50	9.75	9.68
Interpretation of the Music	1.00	10.00	9.75	10.00	9.75	9.50	9.50	9.50	9.50	9.50	9.64
Judges Total Program Component Score (factored)											**47.99**

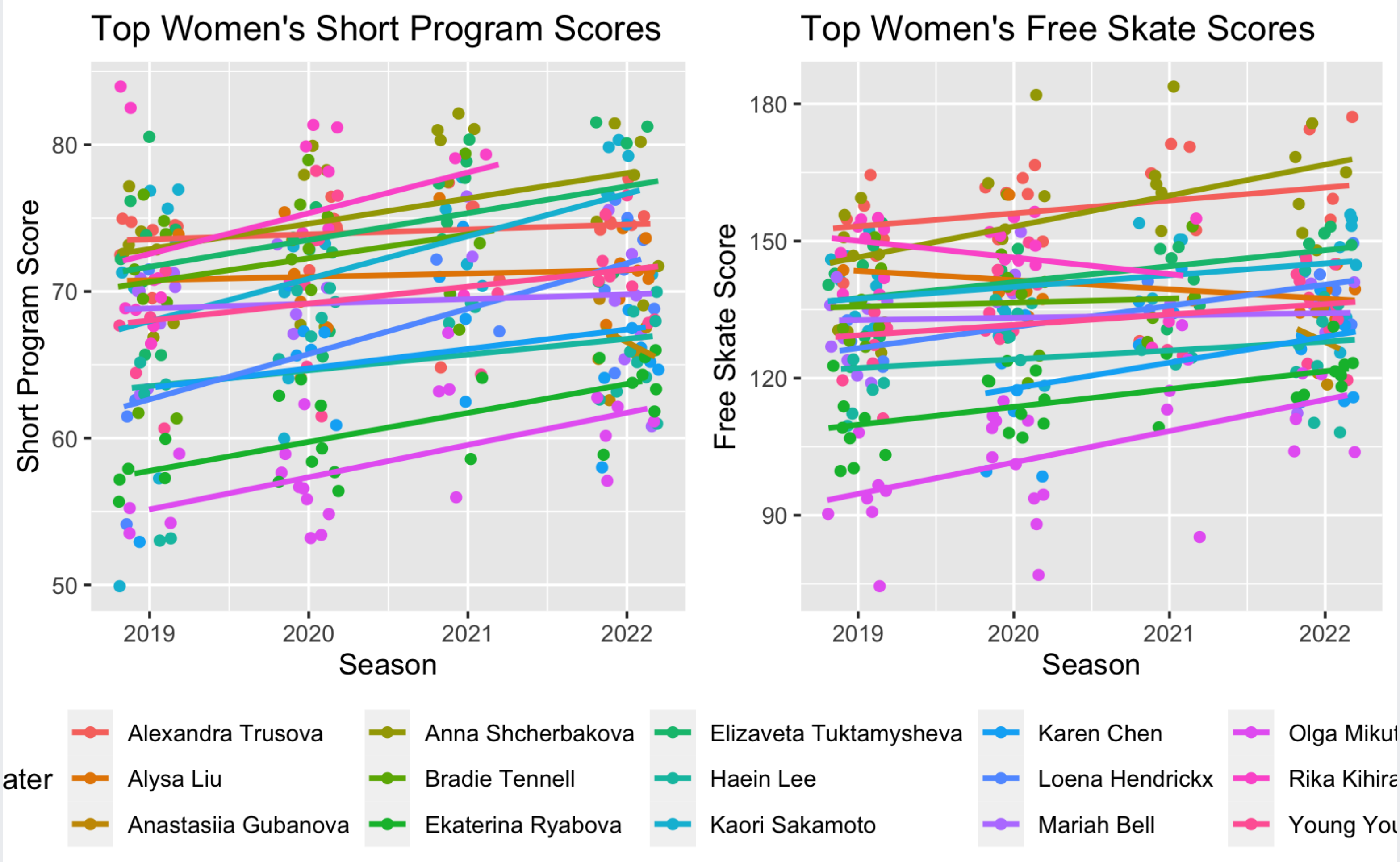
Deductions: **0.00**

Data Cleaning

- all_men: 646 obs of 13 var
- all_women: 618 obs of 13 var
- all_pairs: 448 obs of 13 var
- all_dance: 495 obs of 13 var
- added random jitter to the seasons when conducting EDA

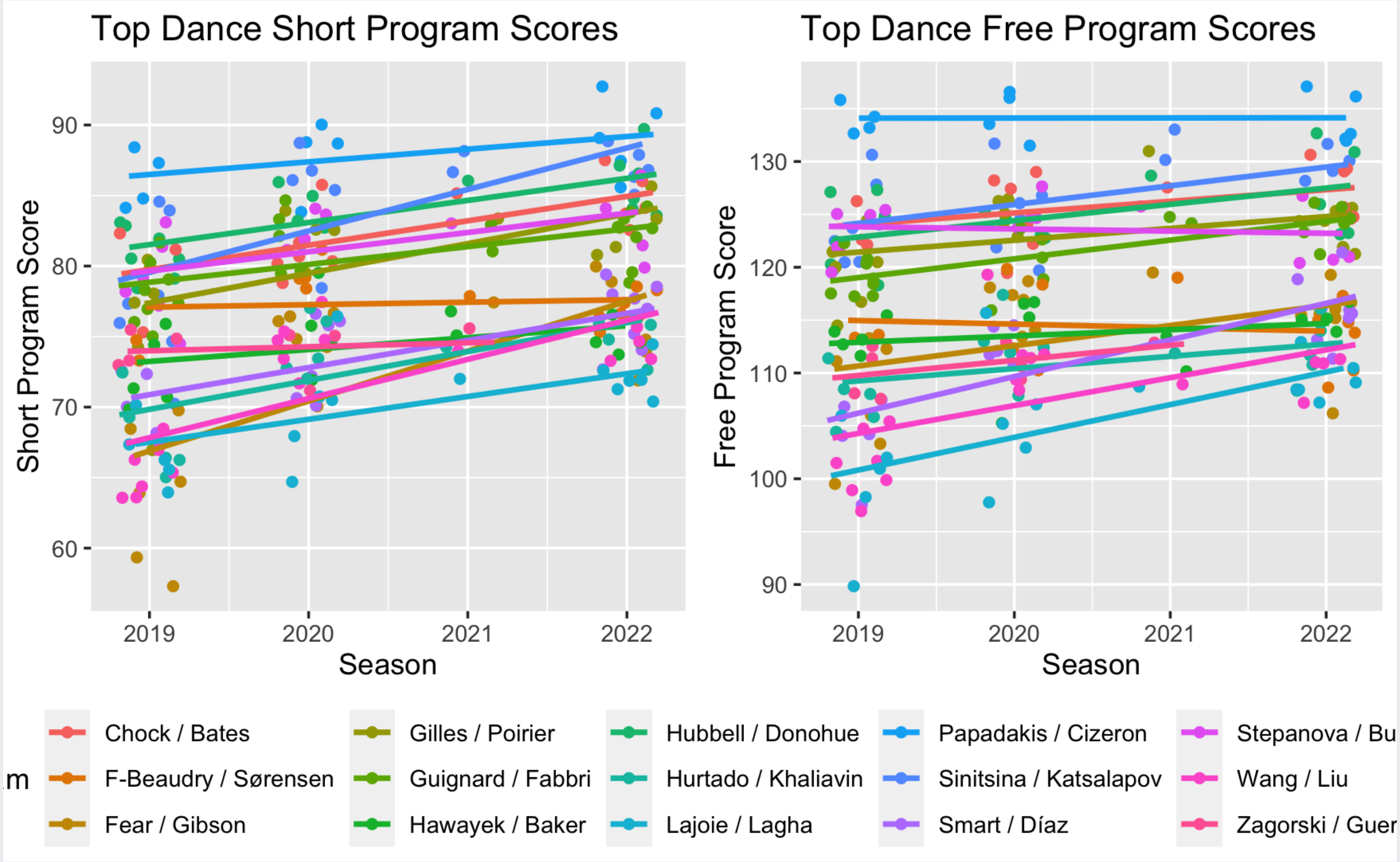
Initial EDA


Top Men's Short Program Scores
Short Program Score
100
80
60
2019
2020
2021
2022
Season
Top Men's Free Program Scores
Free Program Score
210
180
150
120
2019
2020
2021
2022
Season
Skater
Adam Siao Him Fa
Camden Pulkinen
Daniel Grassl
Evgeni Semenenko
Jason Brown
Kazuki Tomono
Keegan Messing
Kévin Aymoz
Mikhail Kolyada
Morisi Kvitelashvili
Nathan Chen
Shoma Uno
Vincent Zhou
Yuma Kagiyama
Yuzuru Hanyu



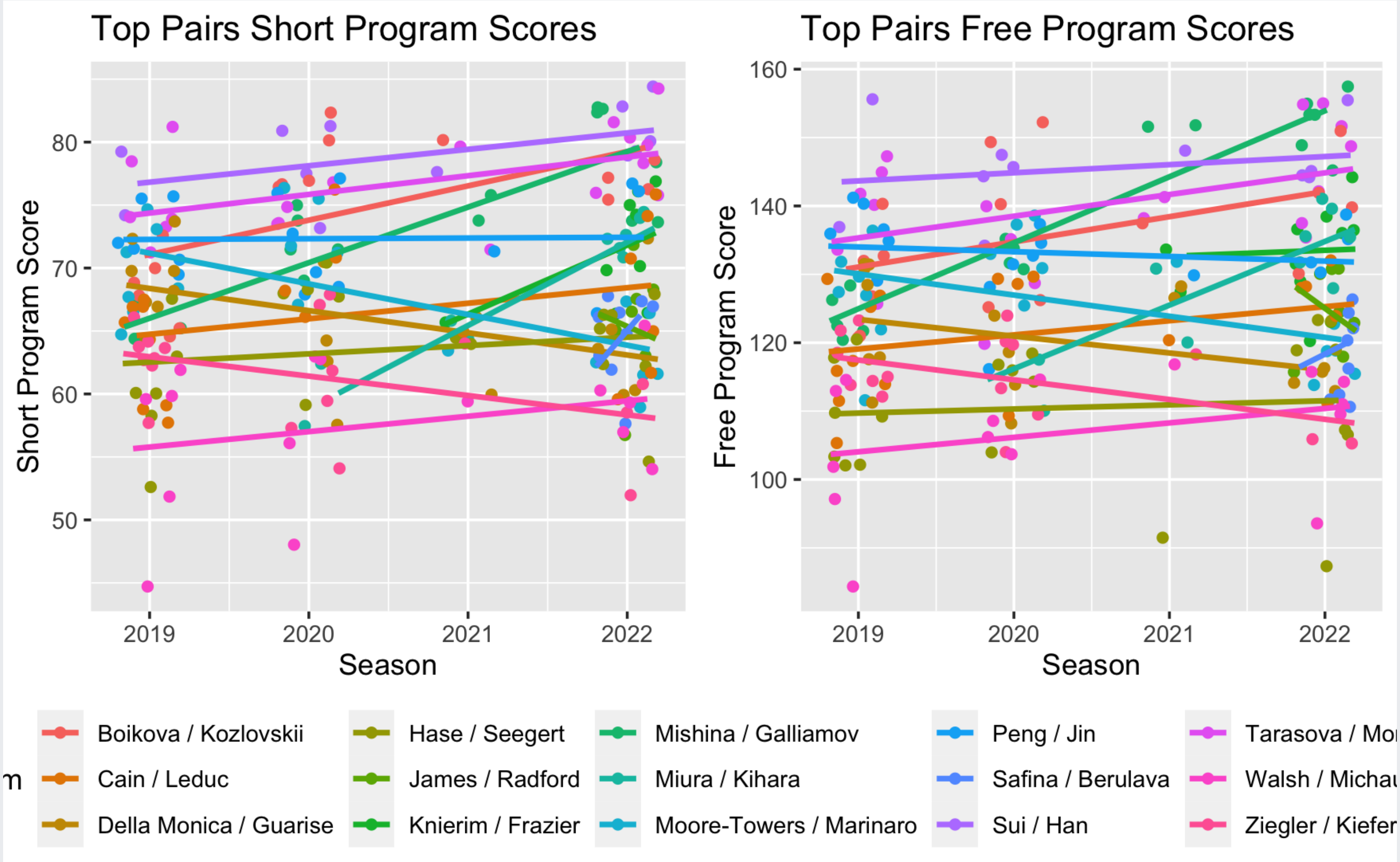
Observations:

- Chen and Hanyu dominate in the men's discipline
- Women's discipline has less consistent champions
- We see many intersecting lines and much movement across seasons



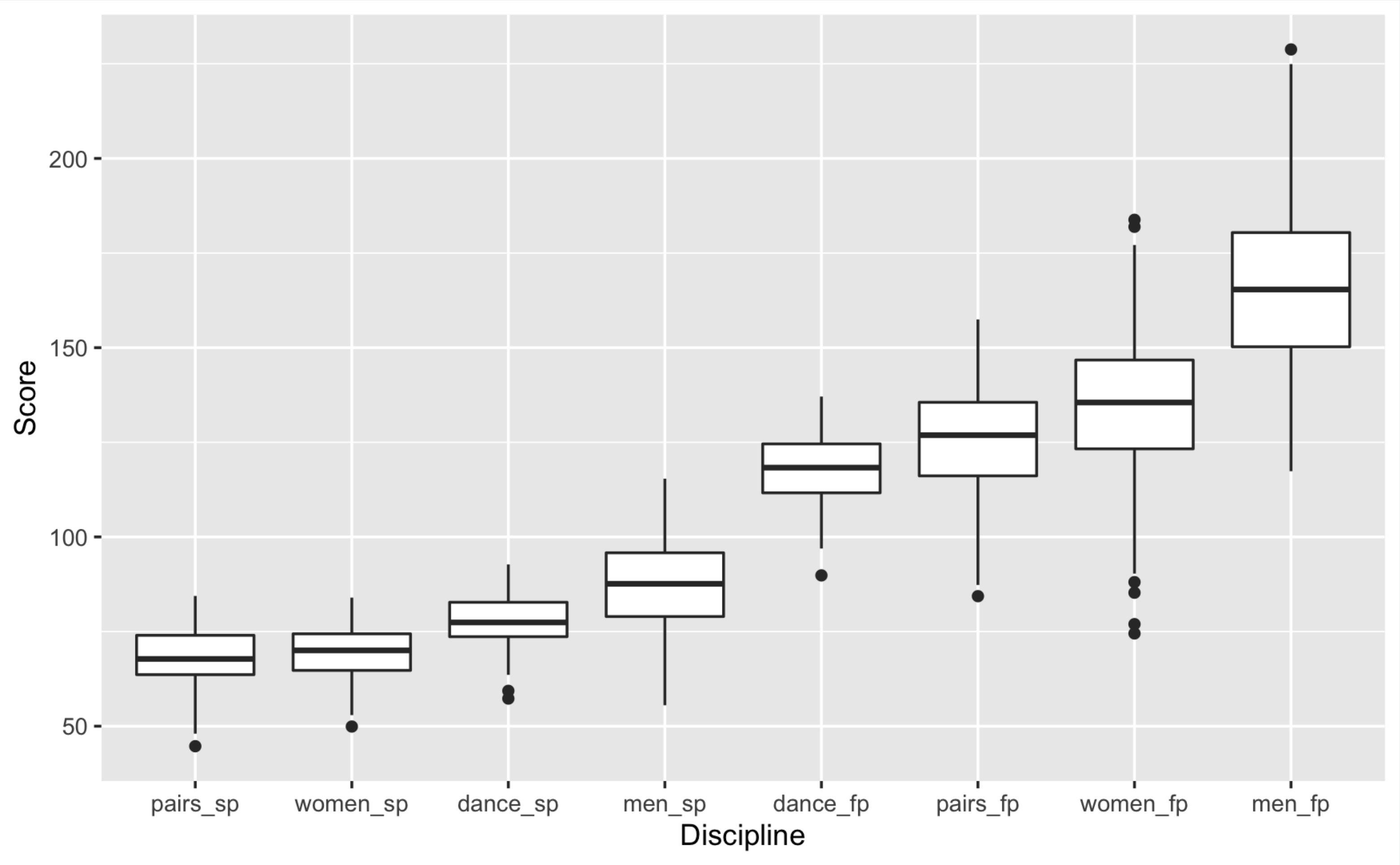
Observations:

- Much more consistent rankings across seasons and teams
- Smaller range of scores
- Differences between scores diminish in recent years



Observations:

- Fewer data points during the 2021 season due to COVID
- Generally consistent rankings across seasons



Observations:

- Dance scores have lower variance than other discplines
- Men's scores are higher and consist of more outliers

Modeling Plan

Prediction

- OLS: outcome is the final score, predictors: mean GOE mark, mean PCS mark Each segment is normally distributed based on the predictors, previous personal best (h_{short}), mean GOE (goe_i), and mean PCS (pcs_i). *Note PB is not included yet

$$\text{short}_i \sim N(\beta_{0,short} + \beta_{1,short} * h_{short} + \beta_2 * \text{goe}_i + \beta_3 * \text{pcs}_i, \sigma^2_{short})$$

$$\text{long}_i \sim N(\beta_{0,long} + \beta_{1,long} * h_{long} + \beta_2 * \text{goe}_i + \beta_3 * \text{pcs}_i, \sigma^2_{long})$$

- Mixed effects model: incorporate home-town advantage, starting order

Judging Bias

- Use Spearman's Rank Correlation to assess how judges' rankings line up with the final skater rankings
- Bayesian generalized linear model (stan_glm) to check for a correlation between competing in home country and final score: $y = f(\beta_0 + \beta_1 * \text{home})$

Results

```
summary(lm(TES ~ MeanGOE.Mark + MeanPCS.Mark, data = fp_men))
```

```
##
## Call:
## lm(formula = TES ~ MeanGOE.Mark + MeanPCS.Mark, data = fp_men)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -26.1184  -6.5738   0.4681   6.6633  27.1024
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   32.3652     7.2009   4.495 9.70e-06 ***
## MeanGOE.Mark   7.0387     0.8011   8.786  < 2e-16 ***
## MeanPCS.Mark   4.9022     0.9744   5.031 8.07e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.641 on 326 degrees of freedom
## Multiple R-squared:  0.5472,	Adjusted R-squared:  0.5444
## F-statistic:   197 on 2 and 326 DF,  p-value: < 2.2e-16
```

```r
summary(lm(TES ~ MeanGOE.Mark + MeanPCS.Mark, data = sp_men))
```

```
##
## Call:
## lm(formula = TES ~ MeanGOE.Mark + MeanPCS.Mark, data = sp_men)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -16.6297  -3.0178   0.2811   4.3390   9.5421
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   16.9989     3.6978   4.597 6.22e-06 ***
## MeanGOE.Mark   4.6288     0.3697  12.519  < 2e-16 ***
## MeanPCS.Mark   2.3832     0.5077   4.694 4.00e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.383 on 314 degrees of freedom
## Multiple R-squared:  0.641,    Adjusted R-squared:  0.6388
## F-statistic: 280.4 on 2 and 314 DF,  p-value: < 2.2e-16
```

Spearman rank correlations

X	final_placement	Skater	nation	CAN	EST	SWE	ITA	TUR	AUT	FRA	AZE	KAZ
2	1	Shoma UNO		1	1	1	1	1	1	1	1	1
3	2	Yuma KAGIYAMA		2	2	2	4	2	2	2	2	2
4	3	Camden PULKINEN		4	3	4	3	4	3	5	6	5
5	4	Vincent ZHOU		3	5	3	5	3	5	3	4	4
6	5	Morisi KVITELASHVILI		5	4	5	2	7	7	4	3	3
7	6	Adam SIAO HIM FA		7	6	6	6	5	4	6	5	6
10	7	Daniel GRASSL		6	7	9	9	6	8	7	11	9
11	8	Kazuki TOMONO		9	9	7	7	8	6	11	7	7
12	9	Roman SADOVSKY		8	10	8	11	10	11	9	8	11
13	10	Matteo RIZZO		10	11	10	8	11	9	10	9	10

The high correlations indicate that judges generally agree with each other, but we note that the Italian judge has the lowest correlation.

In the final paper I will test for whether this statistic is significantly lower than the correlations of the other judges.

countries_men <chr>	corr_men <dbl>
CAN	0.9871542
EST	0.9812253
SWE	0.9871542
ITA	0.9792490
TUR	0.9871542
AUT	0.9802372
FRA	0.9832016
AZE	0.9812253
KAZ	0.9832016

Home Country Advantage

Regression of Host Country		
How Competing in Their Home Country Affects Mens' Scores		
Characteristic	**Beta**	**95% CI**[1]
(Intercept)	218	214, 222
Home	21	7.5, 34

[1] CI = Confidence Interval

Regression of Host Country		
How Competing in Their Home Country Affects Ladies Scores		
Characteristic	**Beta**	**95% CI**[1]
(Intercept)	162	159, 165
Home	22	11, 34

[1] CI = Confidence Interval

Confidence interval does not contain 0

Regression of Host Country		
How Competing in Their Home Country Affects Pairs Scores		
Characteristic	**Beta**	**95% CI**[1]
(Intercept)	176	172, 180
Home	8.9	-4.3, 22

[1] CI = Confidence Interval

Regression of Host Country		
How Competing in Their Home Country Affects Dance Scores		
Characteristic	**Beta**	**95% CI**[1]
(Intercept)	164	161, 166
Home	9.3	-0.73, 20

[1] CI = Confidence Interval

Confidence interval contains 0

Discussion & Limitations

Prediction

- Grade of Execution and Program Component Scores are strong indicators of final score, although GOE holds a stronger weight (beta coefficient = 4.63 for GOE vs. 2.38 for PCS)
- These beta coefficients are highly significant

Bias

- There is a strong indication of advantage for skaters competing in their hometown, but this may be conflated with the fact that countries with top skaters are more likely to host competitions
- Judges have generally high agreeability, but we should look further into whether low correlations are significant results