

# HW 6

Yoonseo Mok

```
library(DBI)
library(parallel)
library(future)
library(data.table)

# Import the SQLite database of the Lahman data
lahman <- dbConnect(RSQLite::SQLite(), "lahman_1871-2022.sqlite")

# Reading in fielding data
Fielding=dbGetQuery(lahman, "SELECT * FROM Fielding")
# Calculating Range Factor
Fielding$RF=3*(Fielding$PO+Fielding$A)/Fielding$InnOuts
# Data cleaning
fielding=na.omit(Fielding[, c("teamID", "RF")])
fielding=fielding[!is.infinite(fielding$RF),]

# Calculating the average RF for each team
point_est=aggregate(fielding$RF,by=list(fielding$teamID), FUN =mean)
colnames(point_est)=c("teamID", "meanRF")
```

A

```
fielding_dat=data.table(fielding)

# Bootstrap using data.table
f = function(data) {
  tmp=data[,.SD[sample(.N, replace=TRUE)], by=teamID]
  return(tmp[,.(meanRF = mean(RF)), by=teamID])
}

# Checking the function
f(fielding_dat)
```

```
##      teamID    meanRF
##      <char>    <num>
##    1:    SFN 0.3994009
##    2:    CHN 0.4191847
##    3:    CHA 0.4110353
##    4:    BOS 0.4011627
##    5:    SEA 0.3895647
```

```
## ---
## 136:    NYP 0.4916552
## 137:    PHP 0.4004616
## 138:    IN1 0.4022130
## 139:    RIC 0.4901255
## 140:    BL4 0.4171971

# Measuring time
system.time(f(fielding_dat))
```

```
##      user  system elapsed
## 0.012   0.000   0.012
```

## A1: Without any parallel processing

```
reps=1000

# Using lapply
system.time({
  result1=lapply(seq_len(reps), function(x) f(fielding_dat))
})
```

```
##      user  system elapsed
## 11.333   0.380  11.741
```

## A2: Using parallel processing with the parallel package

```
# Using mclapply
system.time({
  result2=mclapply(seq_len(reps), function(x) f(fielding_dat), mc.cores=5)
})
```

```
##      user  system elapsed
##  2.516   0.107   2.620
```

## A3: Using futures with the future package

```
# Using future
plan(multisession)
system.time({
  result3=lapply(seq_len(reps), function(x) {
    future(f(fielding_dat), seed=TRUE)
  })
  result3 =lapply(result3,value)
})
```

```
##      user  system elapsed
## 56.482   1.699   72.762
```

## B

```
# Generating a table showing the estimated RF and associated SE from the three approaches.
tablesum <- function(results) {
  bind=rbindlist(results)
  summary=bind[, .(meanRF=mean(meanRF), SE=sd(meanRF)), by=teamID]
  return(summary)
}

# Showing the results
print(tablesum(result1), n = 1e3)
```

```
##      teamID      meanRF      SE
##      <char>      <num>      <num>
## 1:   SFN 0.4015349 0.005576400
## 2:   CHN 0.4152901 0.004700937
## 3:   CHA 0.4060179 0.005345566
## 4:   BOS 0.4018613 0.005454603
## 5:   SEA 0.3870921 0.006638321
## 6:   NYA 0.4040953 0.005252083
## 7:   NYN 0.4023736 0.005474562
## 8:   ATL 0.3885563 0.005847744
## 9:   ML1 0.4410696 0.014390117
## 10:  ML4 0.4140173 0.009402126
## 11:  CAL 0.4160819 0.008077918
## 12:  BAL 0.3925398 0.005272292
## 13:  LAN 0.3948526 0.005929343
## 14:  OAK 0.4034366 0.007203158
## 15:  HOU 0.4014197 0.006056666
## 16:  WAS 0.3736107 0.007837520
## 17:  MIN 0.3917392 0.005686724
## 18:  PH3 0.4680075 0.086817566
## 19:  BR2 0.3989138 0.025233686
## 20:  PHI 0.4007781 0.004878598
## 21:  BSN 0.4564511 0.009244712
## 22:  PIT 0.4110345 0.004678973
## 23:  BRO 0.4424648 0.010213409
## 24:  TL2 0.4215740 0.061557790
## 25:  CLE 0.4006725 0.005559649
## 26:  DET 0.4068761 0.005031840
## 27:  FLO 0.3700736 0.009753119
## 28:  MIL 0.3591490 0.008067752
## 29:  COL 0.3894042 0.008048300
## 30:  SLN 0.4196248 0.005175266
## 31:  KCA 0.3906335 0.006208994
## 32:  TBA 0.3565061 0.008136211
## 33:  KC1 0.4069286 0.012420019
## 34:  TRO 0.4722016 0.040549803
```

##	35:	WS1	0.4638371	0.012170138
##	36:	CIN	0.4034296	0.004925843
##	37:	SLA	0.4664150	0.016809514
##	38:	SDN	0.3937675	0.005959054
##	39:	TEX	0.3853478	0.006135075
##	40:	LAA	0.3756819	0.009367655
##	41:	ARI	0.3656083	0.008644576
##	42:	TOR	0.3750433	0.006450714
##	43:	SR1	0.4666081	0.041013798
##	44:	SL4	0.4367566	0.016689114
##	45:	RC1	0.5758846	0.082255509
##	46:	PH2	0.4628995	0.033771950
##	47:	BS1	0.4497294	0.031480775
##	48:	HR1	0.3831367	0.038512082
##	49:	CN1	0.4407548	0.022858904
##	50:	MIA	0.3635028	0.012236105
##	51:	TRN	0.4798807	0.028978885
##	52:	BL2	0.4017793	0.015076114
##	53:	SE1	0.4157792	0.045271163
##	54:	PT1	0.4423403	0.023449838
##	55:	WSU	0.4002284	0.033123245
##	56:	CL3	0.4596358	0.029816898
##	57:	ML3	0.4661121	0.064206950
##	58:	MON	0.4169071	0.008474087
##	59:	KCU	0.4160218	0.032298192
##	60:	ANA	0.4156843	0.016160225
##	61:	WS2	0.3980689	0.013093108
##	62:	MID	0.4598707	0.061820347
##	63:	CL2	0.4350478	0.021919887
##	64:	NY1	0.4405127	0.009007938
##	65:	KC2	0.3808563	0.024998349
##	66:	CL4	0.4454930	0.016278886
##	67:	BR1	0.4407512	0.043079693
##	68:	CL1	0.3858983	0.037839412
##	69:	ELI	0.5284436	0.062678493
##	70:	WS6	0.4133443	0.054565079
##	71:	LS1	0.5312578	0.057662277
##	72:	WS3	0.4117975	0.045920537
##	73:	NY2	0.3914053	0.022868260
##	74:	HAR	0.4161732	0.047201617
##	75:	PRO	0.4645004	0.022133677
##	76:	LS3	0.4891696	0.015563878
##	77:	SL5	0.3741315	0.029436787
##	78:	WS9	0.4374701	0.036634500
##	79:	BLN	0.4498992	0.018693661
##	80:	MLA	0.4182391	0.038574494
##	81:	IN3	0.4201404	0.028934173
##	82:	BRP	0.4366000	0.054459711
##	83:	CN3	0.4339689	0.048876540
##	84:	LS2	0.4727014	0.016364133
##	85:	PH1	0.4536430	0.026310707
##	86:	PHA	0.4654655	0.016884726
##	87:	FW1	0.4424588	0.051102856
##	88:	BLA	0.4968395	0.032041893

##	89:	PH4	0.4124331	0.015448272
##	90:	TL1	0.4547964	0.046819198
##	91:	WS8	0.4468635	0.021907068
##	92:	CHU	0.3425915	0.036434341
##	93:	BLU	0.3846633	0.041735394
##	94:	WS5	0.4061112	0.051621736
##	95:	IN2	0.4629092	0.046152570
##	96:	PHU	0.4831435	0.046580918
##	97:	WIL	0.3770809	0.059666146
##	98:	CLP	0.4057748	0.044723014
##	99:	BL3	0.4439519	0.040674203
##	100:	SLU	0.3930115	0.038094680
##	101:	KCN	0.4385427	0.046923747
##	102:	CN2	0.4375142	0.020066827
##	103:	MLU	0.5204591	0.130654013
##	104:	DTN	0.4226088	0.016914712
##	105:	BFP	0.4648356	0.053327827
##	106:	CL6	0.4119255	0.027326562
##	107:	CHP	0.4778479	0.051187203
##	108:	NH1	0.4420382	0.050973624
##	109:	CNU	0.4434691	0.052235991
##	110:	SPU	0.4672595	0.086307174
##	111:	KEO	0.5057609	0.113287449
##	112:	WS7	0.4502911	0.048918469
##	113:	RC2	0.4757455	0.044814132
##	114:	BL1	0.4421420	0.029587510
##	115:	SL2	0.3926721	0.060623419
##	116:	SL3	0.3968299	0.040422324
##	117:	SR2	0.4135454	0.039671975
##	118:	CL5	0.4414354	0.043132880
##	119:	NY4	0.4417067	0.024589597
##	120:	NY3	0.3793799	0.039606353
##	121:	PTP	0.4489342	0.052859668
##	122:	BR3	0.4481307	0.023135826
##	123:	ML2	0.4400740	0.055727888
##	124:	WOR	0.4247895	0.036148445
##	125:	PHN	0.4505115	0.041088142
##	126:	ALT	0.3872199	0.050423204
##	127:	WS4	0.4644983	0.058670518
##	128:	CH2	0.4381546	0.036705983
##	129:	SL1	0.3373308	0.063639765
##	130:	BSU	0.4209692	0.055648415
##	131:	BR4	0.4367460	0.047873223
##	132:	CH1	0.4296490	0.061222100
##	133:	BFN	0.4517211	0.020586584
##	134:	BSP	0.4289037	0.046898024
##	135:	BS2	0.4322567	0.050334450
##	136:	NYP	0.4235172	0.048018243
##	137:	PHP	0.4398788	0.055577186
##	138:	IN1	0.4080305	0.065150719
##	139:	RIC	0.5084412	0.069146396
##	140:	BL4	0.4312986	0.058675117
##		teamID	meanRF	SE

```
print(tablesุม(result2), n = 1e3)
```

##	teamID	meanRF	SE
##	<char>	<num>	<num>
##	1: SFN	0.4016351	0.005405577
##	2: CHN	0.4151843	0.004829461
##	3: CHA	0.4059439	0.005423491
##	4: BOS	0.4018291	0.005403052
##	5: SEA	0.3866007	0.006604381
##	6: NYA	0.4040344	0.005568047
##	7: NYN	0.4026318	0.005741148
##	8: ATL	0.3878814	0.005882640
##	9: ML1	0.4416124	0.014768927
##	10: ML4	0.4146855	0.008626886
##	11: CAL	0.4166807	0.008024152
##	12: BAL	0.3924150	0.005441389
##	13: LAN	0.3950776	0.005655970
##	14: OAK	0.4026439	0.006794875
##	15: HOU	0.4010830	0.005960326
##	16: WAS	0.3737662	0.008217006
##	17: MIN	0.3914972	0.005814738
##	18: PH3	0.4673439	0.086151510
##	19: BR2	0.3998991	0.025899707
##	20: PHI	0.4010715	0.004470902
##	21: BSN	0.4562451	0.009277930
##	22: PIT	0.4112308	0.004672965
##	23: BRO	0.4422775	0.009854525
##	24: TL2	0.4205241	0.061807379
##	25: CLE	0.4004710	0.005213001
##	26: DET	0.4069891	0.005216982
##	27: FLO	0.3708010	0.010020233
##	28: MIL	0.3587843	0.008180368
##	29: COL	0.3890666	0.008016403
##	30: SLN	0.4197096	0.005140394
##	31: KCA	0.3906608	0.005964145
##	32: TBA	0.3562709	0.007831590
##	33: KC1	0.4088153	0.012847455
##	34: TRO	0.4730101	0.041467889
##	35: WS1	0.4640304	0.011873680
##	36: CIN	0.4030236	0.004731821
##	37: SLA	0.4666826	0.017191840
##	38: SDN	0.3938903	0.005951851
##	39: TEX	0.3854584	0.006053348
##	40: LAA	0.3752530	0.009148275
##	41: ARI	0.3658364	0.008739099
##	42: TOR	0.3750744	0.006432545
##	43: SR1	0.4660787	0.038822947
##	44: SL4	0.4357312	0.017021054
##	45: RC1	0.5754761	0.080067671
##	46: PH2	0.4650872	0.033781033
##	47: BS1	0.4515945	0.030558034
##	48: HR1	0.3807535	0.037918074
##	49: CN1	0.4392277	0.024147877

##	50:	MIA	0.3642582	0.012089373
##	51:	TRN	0.4806900	0.029978605
##	52:	BL2	0.4009704	0.015886346
##	53:	SE1	0.4163435	0.043052893
##	54:	PT1	0.4414847	0.023174876
##	55:	WSU	0.4029012	0.036343493
##	56:	CL3	0.4582535	0.029861449
##	57:	ML3	0.4641774	0.062616754
##	58:	MON	0.4166748	0.008517886
##	59:	KCU	0.4182832	0.030542678
##	60:	ANA	0.4151977	0.016121669
##	61:	WS2	0.3994517	0.012853340
##	62:	MID	0.4593338	0.061071264
##	63:	CL2	0.4352362	0.021801996
##	64:	NY1	0.4395593	0.009454504
##	65:	KC2	0.3811903	0.026714385
##	66:	CL4	0.4446096	0.016248232
##	67:	BR1	0.4367321	0.043226428
##	68:	CL1	0.3856408	0.039061083
##	69:	ELI	0.5245327	0.064741351
##	70:	WS6	0.4199188	0.058254521
##	71:	LS1	0.5285141	0.056081068
##	72:	WS3	0.4088475	0.045054121
##	73:	NY2	0.3904144	0.023756877
##	74:	HAR	0.4176166	0.046689295
##	75:	PRO	0.4637317	0.022233947
##	76:	LS3	0.4890945	0.016290393
##	77:	SL5	0.3744065	0.029320417
##	78:	WS9	0.4387970	0.036569703
##	79:	BLN	0.4479174	0.017988365
##	80:	MLA	0.4179884	0.037773939
##	81:	IN3	0.4191221	0.030120439
##	82:	BRP	0.4327803	0.053428210
##	83:	CN3	0.4348074	0.051105059
##	84:	LS2	0.4730626	0.016446971
##	85:	PH1	0.4541288	0.028120142
##	86:	PHA	0.4663245	0.017706449
##	87:	FW1	0.4414381	0.050230193
##	88:	BLA	0.4948814	0.033463455
##	89:	PH4	0.4126512	0.014980579
##	90:	TL1	0.4554427	0.048639341
##	91:	WS8	0.4482114	0.022131174
##	92:	CHU	0.3444172	0.037050338
##	93:	BLU	0.3833569	0.041967442
##	94:	WS5	0.4087238	0.051638313
##	95:	IN2	0.4617162	0.044385248
##	96:	PHU	0.4812679	0.045900027
##	97:	WIL	0.3799938	0.061686873
##	98:	CLP	0.4047793	0.043423171
##	99:	BL3	0.4466527	0.041662687
##	100:	SLU	0.3892159	0.038596862
##	101:	KCN	0.4398164	0.047981540
##	102:	CN2	0.4387771	0.019820836
##	103:	MLU	0.5173386	0.122921199

```
## 104: DTN 0.4210062 0.016997535
## 105: BFP 0.4634003 0.053214715
## 106: CL6 0.4112039 0.027469914
## 107: CHP 0.4773611 0.052430146
## 108: NH1 0.4409004 0.050818993
## 109: CNU 0.4439930 0.050474625
## 110: SPU 0.4583561 0.087745428
## 111: KEO 0.5126396 0.113361293
## 112: WS7 0.4489202 0.047072338
## 113: RC2 0.4751665 0.043227601
## 114: BL1 0.4417058 0.029395517
## 115: SL2 0.3919804 0.059032011
## 116: SL3 0.3957778 0.039339349
## 117: SR2 0.4112137 0.038309041
## 118: CL5 0.4391769 0.043591135
## 119: NY4 0.4418149 0.024838509
## 120: NY3 0.3810482 0.042005776
## 121: PTP 0.4471835 0.050541502
## 122: BR3 0.4478786 0.022574714
## 123: ML2 0.4419640 0.055607664
## 124: WOR 0.4251699 0.035574394
## 125: PHN 0.4537573 0.040885022
## 126: ALT 0.3870335 0.052053431
## 127: WS4 0.4650375 0.057425722
## 128: CH2 0.4383876 0.036152782
## 129: SL1 0.3390186 0.064778219
## 130: BSU 0.4214176 0.054248183
## 131: BR4 0.4412533 0.047190546
## 132: CH1 0.4310770 0.058327667
## 133: BFN 0.4499234 0.020991653
## 134: BSP 0.4301518 0.047796411
## 135: BS2 0.4302735 0.049100568
## 136: NYP 0.4216060 0.047256184
## 137: PHP 0.4402815 0.056056829
## 138: IN1 0.4050402 0.065196527
## 139: RIC 0.5101037 0.067699011
## 140: BL4 0.4294318 0.059199891
##      teamID      meanRF      SE
```

```
print(tablesุม(result3), n = 1e3)
```

```
##      teamID      meanRF      SE
##      <char>      <num>      <num>
## 1:   SFN 0.4013638 0.005528907
## 2:   CHN 0.4149393 0.004810677
## 3:   CHA 0.4064927 0.005563625
## 4:   BOS 0.4019381 0.005399964
## 5:   SEA 0.3866071 0.006436802
## 6:   NYA 0.4039246 0.005239261
## 7:   NYN 0.4024220 0.005489520
## 8:   ATL 0.3882329 0.005895656
## 9:   ML1 0.4410458 0.015026242
## 10:  ML4 0.4135841 0.008516379
## 11:  CAL 0.4160021 0.008193015
```



##	12:	BAL	0.3928834	0.005507230
##	13:	LAN	0.3951095	0.005790221
##	14:	OAK	0.4033283	0.007032589
##	15:	HOU	0.4013421	0.005894239
##	16:	WAS	0.3739929	0.008160038
##	17:	MIN	0.3916765	0.005802486
##	18:	PH3	0.4659117	0.085498170
##	19:	BR2	0.3995040	0.025777865
##	20:	PHI	0.4011052	0.004638589
##	21:	BSN	0.4560907	0.009381853
##	22:	PIT	0.4111775	0.004813583
##	23:	BRO	0.4429304	0.010006963
##	24:	TL2	0.4181175	0.062579636
##	25:	CLE	0.4003447	0.005066181
##	26:	DET	0.4069788	0.005313747
##	27:	FLO	0.3706371	0.010075861
##	28:	MIL	0.3588312	0.008388794
##	29:	COL	0.3895097	0.007682184
##	30:	SLN	0.4198059	0.004971617
##	31:	KCA	0.3905645	0.005765575
##	32:	TBA	0.3560317	0.007995669
##	33:	KC1	0.4074745	0.012866789
##	34:	TRO	0.4706077	0.042111551
##	35:	WS1	0.4637710	0.012422281
##	36:	CIN	0.4034607	0.004997568
##	37:	SLA	0.4652212	0.017116453
##	38:	SDN	0.3941844	0.006126862
##	39:	TEX	0.3855286	0.006251859
##	40:	LAA	0.3760306	0.009141349
##	41:	ARI	0.3660261	0.008611163
##	42:	TOR	0.3752793	0.006600762
##	43:	SR1	0.4637738	0.040089853
##	44:	SL4	0.4370439	0.016816818
##	45:	RC1	0.5777574	0.083022214
##	46:	PH2	0.4634658	0.034002882
##	47:	BS1	0.4517702	0.031022511
##	48:	HR1	0.3846360	0.039343634
##	49:	CN1	0.4412896	0.023291263
##	50:	MIA	0.3635884	0.012275715
##	51:	TRN	0.4824595	0.029856925
##	52:	BL2	0.4007844	0.015608401
##	53:	SE1	0.4178014	0.043193072
##	54:	PT1	0.4425358	0.023259553
##	55:	WSU	0.4012511	0.033216451
##	56:	CL3	0.4585835	0.028615642
##	57:	ML3	0.4617504	0.060141308
##	58:	MON	0.4172349	0.008678987
##	59:	KCU	0.4198242	0.030399145
##	60:	ANA	0.4148185	0.016027919
##	61:	WS2	0.3993220	0.013076930
##	62:	MID	0.4571217	0.063413534
##	63:	CL2	0.4366374	0.023678545
##	64:	NY1	0.4399681	0.009042365
##	65:	KC2	0.3796933	0.025304495

## 66:	CL4	0.4451297	0.016341804
## 67:	BR1	0.4401994	0.043656101
## 68:	CL1	0.3867940	0.039395498
## 69:	ELI	0.5259988	0.065014438
## 70:	WS6	0.4159940	0.058408796
## 71:	LS1	0.5302553	0.056524033
## 72:	WS3	0.4106848	0.047233670
## 73:	NY2	0.3903607	0.023780824
## 74:	HAR	0.4170715	0.045233638
## 75:	PRO	0.4649538	0.022193021
## 76:	LS3	0.4885604	0.015766893
## 77:	SL5	0.3760904	0.030731193
## 78:	WS9	0.4393543	0.036139571
## 79:	BLN	0.4498589	0.019454505
## 80:	MLA	0.4180118	0.039280829
## 81:	IN3	0.4188557	0.030457841
## 82:	BRP	0.4312485	0.053367067
## 83:	CN3	0.4366987	0.050076526
## 84:	LS2	0.4736016	0.016043666
## 85:	PH1	0.4543130	0.027605290
## 86:	PHA	0.4654418	0.017566836
## 87:	FW1	0.4378407	0.051855655
## 88:	BLA	0.4964947	0.032018665
## 89:	PH4	0.4126654	0.015397202
## 90:	TL1	0.4541440	0.048157422
## 91:	WS8	0.4460815	0.021530656
## 92:	CHU	0.3427236	0.035626037
## 93:	BLU	0.3831311	0.042533127
## 94:	WS5	0.4082308	0.049940864
## 95:	IN2	0.4627866	0.044543536
## 96:	PHU	0.4775918	0.047536015
## 97:	WIL	0.3834614	0.059218066
## 98:	CLP	0.4058000	0.041843659
## 99:	BL3	0.4442205	0.041221940
## 100:	SLU	0.3905204	0.040481870
## 101:	KCN	0.4417965	0.050041160
## 102:	CN2	0.4387299	0.020665604
## 103:	MLU	0.5101421	0.125767707
## 104:	DTN	0.4206297	0.017532946
## 105:	BFP	0.4627302	0.051928327
## 106:	CL6	0.4101915	0.027961829
## 107:	CHP	0.4770072	0.053664699
## 108:	NH1	0.4420619	0.050179750
## 109:	CNU	0.4469492	0.051991675
## 110:	SPU	0.4640574	0.090971930
## 111:	KEO	0.5119363	0.111291314
## 112:	WS7	0.4482048	0.046377821
## 113:	RC2	0.4753571	0.044674986
## 114:	BL1	0.4393668	0.028090574
## 115:	SL2	0.3961176	0.059072401
## 116:	SL3	0.3960794	0.038445242
## 117:	SR2	0.4127519	0.039210865
## 118:	CL5	0.4378271	0.044348399
## 119:	NY4	0.4436173	0.024403138

## 120:	NY3	0.3796116	0.038381146
## 121:	PTP	0.4480126	0.053413996
## 122:	BR3	0.4473653	0.023098208
## 123:	ML2	0.4391250	0.057148319
## 124:	WOR	0.4243014	0.037109985
## 125:	PHN	0.4503984	0.039965993
## 126:	ALT	0.3854337	0.050716193
## 127:	WS4	0.4653447	0.057719013
## 128:	CH2	0.4381693	0.035886798
## 129:	SL1	0.3382672	0.064193438
## 130:	BSU	0.4176684	0.056430577
## 131:	BR4	0.4385796	0.046533899
## 132:	CH1	0.4268260	0.059656360
## 133:	BFN	0.4500916	0.021395271
## 134:	BSP	0.4321923	0.048507105
## 135:	BS2	0.4340851	0.048001503
## 136:	NYP	0.4206346	0.047725271
## 137:	PHP	0.4402600	0.057768988
## 138:	IN1	0.4079557	0.063855986
## 139:	RIC	0.5063443	0.068706159
## 140:	BL4	0.4303466	0.057412046
##	teamID	meanRF	SE

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