In [218]:
```
using JuMP

function analyzeData(raw)

    N = size(raw)[1]
    raw = raw[2:N, :]

    raw[:,21] = sum(raw[:,i] for i = 13:20)/8
    raw[:,34] = sum(raw[:,i] for i = 22:33)/12
    raw[:,42] = sum(raw[:,i] for i = 35:41)/7

    GKindex = find(raw[:,6].=="GK")    # Rows containing GK's
    LWindex = find(raw[:,6].=="LW")    # Rows containing LW's
    RWindex = find(raw[:,6].=="RW")    # Rows containing RW's
    STindex = find(raw[:,6].=="ST")    # Rows containing ST's
    CFindex = find(raw[:,6].=="CF")    # Rows containing CF's
    CMindex = find(raw[:,6].=="CM")    # Rows containing CM's
    LMindex = find(raw[:,6].=="LM")    # Rows containing LM's
    RMindex = find(raw[:,6].=="RM")    # Rows containing RM's
    CAMindex = find(raw[:,6].=="CAM")  # Rows containing CAM's
    CDMindex = find(raw[:,6].=="CDM")  # Rows containing CDM's
    CBindex = find(raw[:,6].=="CB")    # Rows containing CB's
    LBindex = find(raw[:,6].=="LB")    # Rows containing LB's
    RBindex = find(raw[:,6].=="RB")    # Rows containing RB's

    for i in [LWindex, RWindex, STindex, CFindex]
        raw[i, 21] = raw[i, 1]
    end

    for i in [CMindex, LMindex, RMindex, CAMindex, CDMindex]
        raw[i, 34] = raw[i, 1]
    end

    for i in [CBindex, LBindex, RBindex, GKindex]
        raw[i, 42] = raw[i, 1]
    end

    return raw
end;
```

In [219]:
```
using JuMP, Cbc

function attackModel(λ, TMlimit, maxSalary, raw)

    N = size(raw)[1]                    # Number of players
    GKindex = find(raw[:,6].=="GK")     # Rows containing GK's
    LWindex = find(raw[:,6].=="LW")     # Rows containing LW's
    RWindex = find(raw[:,6].=="RW")     # Rows containing RW's
    STindex = find(raw[:,6].=="ST")     # Rows containing ST's
    CFindex = find(raw[:,6].=="CF")     # Rows containing CF's
    CMindex = find(raw[:,6].=="CM")     # Rows containing CM's
    LMindex = find(raw[:,6].=="LM")     # Rows containing LM's
    RMindex = find(raw[:,6].=="RM")     # Rows containing RM's
    CAMindex = find(raw[:,6].=="CAM")   # Rows containing CAM's
    CDMindex = find(raw[:,6].=="CDM")   # Rows containing CDM's
    CBindex = find(raw[:,6].=="CB")     # Rows containing CB's
    LBindex = find(raw[:,6].=="LB")     # Rows containing LB's
    RBindex = find(raw[:,6].=="RB")     # Rows containing RB's

    clubs = unique(raw[:,7])            # List of unique clubs of the players
    Num = 11                            # Total players in a team
    T = length(clubs)                   # Number of unique clubs
    minLimit = 0                        # Minimum number of player in every position (0)
    minForward = 1                      # Minimum number of forward players(including LW, RW, ST, CF)
    maxForward = 3                      # Maximum number of forward players(including LW, RW, ST, CF)
    minMid = 3                          # Minimum number of midfield players(including CM, CAM, CDM, LM, RM)
    maxMid = 5                          # Maximum number of midfield players(including CM, CAM, CDM, LM, RM)
    minBack = 2                         # Minimum number of back players(including CB, LB, RB)
    maxBack = 4                         # Maximum number of back players(including CB, LB, RB)

    # Maximum number of player in every position
    GKlimit = LWlimit = RWlimit = STlimit = CFlimit = CMlimit = CAMlimit = 1
    CDMlimit = LMlimit = RMlimit = CAMlimit =  LBlimit = RBlimit = 1
    CBlimit = 2

    m = Model(solver=CbcSolver())

    @variable(m, k[1:N], Bin)             # Indicator variable:  1- Player on team, 0- Player not on team
    @constraint(m, sum{k[i]*raw[i,2], i=1:N} <= maxSalary)           # Salary cap constraint
    @constraint(m, sum{k[i], i = GKindex} == GKlimit)                # Number of GK's constraint
    @constraint(m, minLimit <= sum{k[i], i = LWindex} <= LWlimit)    # Number of LW's constraint
```

```
    @constraint(m, minLimit <= sum{k[i], i = RWindex} <= RWlimit)    # Number of RW's constraint
    @constraint(m, minLimit <= sum{k[i], i = STindex} <= STlimit)    # Number of ST's constraint
    @constraint(m, minLimit <= sum{k[i], i = CFindex} <= CFlimit)    # Number of CF's constraint
    @constraint(m, minLimit <= sum{k[i], i = CMindex} <= CMlimit)    # Number of CM's constraint
    @constraint(m, minLimit <= sum{k[i], i = LMindex} <= LMlimit)    # Number of LM's constraint
    @constraint(m, minLimit <= sum{k[i], i = RMindex} <= RMlimit)    # Number of RM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CAMindex} <= CAMlimit)  # Number of CAM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CDMindex} <= CDMlimit)  # Number of CDM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CBindex} <= CBlimit)    # Number of CB's constraint
    @constraint(m, minLimit <= sum{k[i], i = LBindex} <= LBlimit)    # Number of LB's constraint
    @constraint(m, minLimit <= sum{k[i], i = RBindex} <= RBlimit)    # Number of RB's constraint

    # Number of players(forward, midfield and back)constraint
    @constraint(m, minForward <= sum{k[i], i = [LWindex; RWindex; STindex; CFindex]} <= maxForward)
    @constraint(m, minMid <= sum{k[i], i = [CMindex; LMindex; RMindex; CAMindex; CDMindex]} <= maxMid)
    @constraint(m, minBack <= sum{k[i], i = [CBindex; LBindex; RBindex]} <= maxBack)

    # Total number of players must be Num (11)
    @constraint(m, sum{k[i], i = [GKindex; LWindex; RWindex; STindex; CFindex; CMindex; LMindex; RMindex; CAMindex; CDMin
                                                CBindex; LBindex; RBindex]} == Num)

    # Limit amount of players from one particular team
    for t = 1:T
        teamIndex = find(raw[:,7].==clubs[t])
        @constraint(m, sum{k[i], i = teamIndex} <= TMlimit)
    end

    # Maximize the overall ability according to the value of λ
    @objective(m, Max, λ*sum{k[i]*raw[i,21], i=1:N} + (1-λ)/2*(sum{k[i]*raw[i,34], i=1:N} + sum{k[i]*raw[i,42], i=1:N}))

    solve(m);

    Ra = getvalue(sum(k.*raw[:,21]/Num))  # Average attack ability
    Rm = getvalue(sum(k.*raw[:,34]/Num))  # Average midfield ability
    Rd = getvalue(sum(k.*raw[:,42]/Num))  # Average defensive ability
    R = getvalue(sum(k.*raw[:,1]/Num))    # Average overall ability
    Ip = getvalue(k)                    # Indicator player vector

    return(R, Ra, Rm, Rd, Ip)
end;
```

In [220]:
```
using JuMP, Cbc

function midfieldModel(λ, TMlimit, maxSalary, raw)

    N = size(raw)[1]                    # Number of players
    GKindex = find(raw[:,6].=="GK")     # Rows containing GK's
    LWindex = find(raw[:,6].=="LW")     # Rows containing LW's
    RWindex = find(raw[:,6].=="RW")     # Rows containing RW's
    STindex = find(raw[:,6].=="ST")     # Rows containing ST's
    CFindex = find(raw[:,6].=="CF")     # Rows containing CF's
    CMindex = find(raw[:,6].=="CM")     # Rows containing CM's
    LMindex = find(raw[:,6].=="LM")     # Rows containing LM's
    RMindex = find(raw[:,6].=="RM")     # Rows containing RM's
    CAMindex = find(raw[:,6].=="CAM")   # Rows containing CAM's
    CDMindex = find(raw[:,6].=="CDM")   # Rows containing CDM's
    CBindex = find(raw[:,6].=="CB")     # Rows containing CB's
    LBindex = find(raw[:,6].=="LB")     # Rows containing LB's
    RBindex = find(raw[:,6].=="RB")     # Rows containing RB's

    clubs = unique(raw[:,7])            # List of unique clubs of the players
    Num = 11                            # Total players in a team
    T = length(clubs)                   # Number of unique clubs
    minLimit = 0                        # Minimum number of player in every position (0)
    minForward = 1                      # Minimum number of forward players(including LW, RW, ST, CF)
    maxForward = 3                      # Maximum number of forward players(including LW, RW, ST, CF)
    minMid = 3                          # Minimum number of midfield players(including CM, CAM, CDM, LM, RM)
    maxMid = 5                          # Maximum number of midfield players(including CM, CAM, CDM, LM, RM)
    minBack = 2                         # Minimum number of back players(including CB, LB, RB)
    maxBack = 4                         # Maximum number of back players(including CB, LB, RB)

    # Maximum number of player in every position
    GKlimit = LWlimit = RWlimit = STlimit = CFlimit = CMlimit = CAMlimit = 1
    CDMlimit = LMlimit = RMlimit = CAMlimit =  LBlimit = RBlimit = 1
    CBlimit = 2

    m = Model(solver=CbcSolver())

    @variable(m, k[1:N], Bin)             # Indicator variable:  1- Player on team, 0- Player not on team
    @constraint(m, sum{k[i]*raw[i,2], i=1:N} <= maxSalary)          # Salary cap constraint
    @constraint(m, sum{k[i], i = GKindex} == GKlimit)               # Number of GK's constraint
    @constraint(m, minLimit <= sum{k[i], i = LWindex} <= LWlimit)   # Number of LW's constraint
```

```
    @constraint(m, minLimit <= sum{k[i], i = RWindex} <= RWlimit)    # Number of RW's constraint
    @constraint(m, minLimit <= sum{k[i], i = STindex} <= STlimit)    # Number of ST's constraint
    @constraint(m, minLimit <= sum{k[i], i = CFindex} <= CFlimit)    # Number of CF's constraint
    @constraint(m, minLimit <= sum{k[i], i = CMindex} <= CMlimit)    # Number of CM's constraint
    @constraint(m, minLimit <= sum{k[i], i = LMindex} <= LMlimit)    # Number of LM's constraint
    @constraint(m, minLimit <= sum{k[i], i = RMindex} <= RMlimit)    # Number of RM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CAMindex} <= CAMlimit)  # Number of CAM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CDMindex} <= CDMlimit)  # Number of CDM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CBindex} <= CBlimit)    # Number of CB's constraint
    @constraint(m, minLimit <= sum{k[i], i = LBindex} <= LBlimit)    # Number of LB's constraint
    @constraint(m, minLimit <= sum{k[i], i = RBindex} <= RBlimit)    # Number of RB's constraint

    # Number of players(forward, midfield and back)constraint
    @constraint(m, minForward <= sum{k[i], i = [LWindex; RWindex; STindex; CFindex]} <= maxForward)
    @constraint(m, minMid <= sum{k[i], i = [CMindex; LMindex; RMindex; CAMindex; CDMindex]} <= maxMid)
    @constraint(m, minBack <= sum{k[i], i = [CBindex; LBindex; RBindex]} <= maxBack)

    # Total number of players must be Num (11)
    @constraint(m, sum{k[i], i = [GKindex; LWindex; RWindex; STindex; CFindex; CMindex; LMindex; RMindex; CAMindex; CDMin
                                                  CBindex; LBindex; RBindex]} == Num)

    # Limit amount of players from one particular team
    for t = 1:T
        teamIndex = find(raw[:,7].==clubs[t])
        @constraint(m, sum{k[i], i = teamIndex} <= TMlimit)
    end

    # Maximize the overall ability according to the value of λ
    @objective(m, Max, λ*sum{k[i]*raw[i,34], i=1:N} + (1-λ)/2*(sum{k[i]*raw[i,21], i=1:N} + sum{k[i]*raw[i,42], i=1:N}))

    solve(m);

    Ra = getvalue(sum(k.*raw[:,21]/Num))  # Average attack ability
    Rm = getvalue(sum(k.*raw[:,34]/Num))  # Average midfield ability
    Rd = getvalue(sum(k.*raw[:,42]/Num))  # Average defensive ability
    R = getvalue(sum(k.*raw[:,1]/Num))    # Average overall ability
    Ip = getvalue(k)                    # Indicator player vector

    return(R, Ra, Rm, Rd, Ip)
end;
```

In [221]:
```
using JuMP, Cbc

function defendModel(λ, TMlimit, maxSalary, raw)

    N = size(raw)[1]                    # Number of players
    GKindex = find(raw[:,6].=="GK")     # Rows containing GK's
    LWindex = find(raw[:,6].=="LW")     # Rows containing LW's
    RWindex = find(raw[:,6].=="RW")     # Rows containing RW's
    STindex = find(raw[:,6].=="ST")     # Rows containing ST's
    CFindex = find(raw[:,6].=="CF")     # Rows containing CF's
    CMindex = find(raw[:,6].=="CM")     # Rows containing CM's
    LMindex = find(raw[:,6].=="LM")     # Rows containing LM's
    RMindex = find(raw[:,6].=="RM")     # Rows containing RM's
    CAMindex = find(raw[:,6].=="CAM")   # Rows containing CAM's
    CDMindex = find(raw[:,6].=="CDM")   # Rows containing CDM's
    CBindex = find(raw[:,6].=="CB")     # Rows containing CB's
    LBindex = find(raw[:,6].=="LB")     # Rows containing LB's
    RBindex = find(raw[:,6].=="RB")     # Rows containing RB's

    clubs = unique(raw[:,7])            # List of unique clubs of the players
    Num = 11                            # Total players in a team
    T = length(clubs)                   # Number of unique clubs
    minLimit = 0                        # Minimum number of player in every position (0)
    minForward = 1                      # Minimum number of forward players(including LW, RW, ST, CF)
    maxForward = 3                      # Maximum number of forward players(including LW, RW, ST, CF)
    minMid = 3                          # Minimum number of midfield players(including CM, CAM, CDM, LM, RM)
    maxMid = 5                          # Maximum number of midfield players(including CM, CAM, CDM, LM, RM)
    minBack = 2                         # Minimum number of back players(including CB, LB, RB)
    maxBack = 4                         # Maximum number of back players(including CB, LB, RB)

    # Maximum number of player in every position
    GKlimit = LWlimit = RWlimit = STlimit = CFlimit = CMlimit = CAMlimit = 1
    CDMlimit = LMlimit = RMlimit = CAMlimit =  LBlimit = RBlimit = 1
    CBlimit = 2

    m = Model(solver=CbcSolver())

    @variable(m, k[1:N], Bin)             # Indicator variable:  1- Player on team, 0- Player not on team
    @constraint(m, sum{k[i]*raw[i,2], i=1:N} <= maxSalary)          # Salary cap constraint
    @constraint(m, sum{k[i], i = GKindex} == GKlimit)               # Number of GK's constraint
    @constraint(m, minLimit <= sum{k[i], i = LWindex} <= LWlimit)    # Number of LW's constraint
```

```
    @constraint(m, minLimit <= sum{k[i], i = RWindex} <= RWlimit)    # Number of RW's constraint
    @constraint(m, minLimit <= sum{k[i], i = STindex} <= STlimit)    # Number of ST's constraint
    @constraint(m, minLimit <= sum{k[i], i = CFindex} <= CFlimit)    # Number of CF's constraint
    @constraint(m, minLimit <= sum{k[i], i = CMindex} <= CMlimit)    # Number of CM's constraint
    @constraint(m, minLimit <= sum{k[i], i = LMindex} <= LMlimit)    # Number of LM's constraint
    @constraint(m, minLimit <= sum{k[i], i = RMindex} <= RMlimit)    # Number of RM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CAMindex} <= CAMlimit)  # Number of CAM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CDMindex} <= CDMlimit)  # Number of CDM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CBindex} <= CBlimit)    # Number of CB's constraint
    @constraint(m, minLimit <= sum{k[i], i = LBindex} <= LBlimit)    # Number of LB's constraint
    @constraint(m, minLimit <= sum{k[i], i = RBindex} <= RBlimit)    # Number of RB's constraint

    # Number of players(forward, midfield and back)constraint
    @constraint(m, minForward <= sum{k[i], i = [LWindex; RWindex; STindex; CFindex]} <= maxForward)
    @constraint(m, minMid <= sum{k[i], i = [CMindex; LMindex; RMindex; CAMindex; CDMindex]} <= maxMid)
    @constraint(m, minBack <= sum{k[i], i = [CBindex; LBindex; RBindex]} <= maxBack)

    # Total number of players must be Num (11)
    @constraint(m, sum{k[i], i = [GKindex; LWindex; RWindex; STindex; CFindex; CMindex; LMindex; RMindex; CAMindex; CDMin
                                                CBindex; LBindex; RBindex]} == Num)

    # Limit amount of players from one particular team
    for t = 1:T
        teamIndex = find(raw[:,7].==clubs[t])
        @constraint(m, sum{k[i], i = teamIndex} <= TMlimit)
    end

    # Maximize the overall ability according to the value of λ
    @objective(m, Max, λ*sum{k[i]*raw[i,42], i=1:N} + (1-λ)/2*(sum{k[i]*raw[i,21], i=1:N} + sum{k[i]*raw[i,34], i=1:N}))

    solve(m);

    Ra = getvalue(sum(k.*raw[:,21]/Num))  # Average attack ability
    Rm = getvalue(sum(k.*raw[:,34]/Num))  # Average midfield ability
    Rd = getvalue(sum(k.*raw[:,42]/Num))  # Average defensive ability
    R = getvalue(sum(k.*raw[:,1]/Num))    # Average overall ability
    Ip = getvalue(k)                    # Indicator player vector

    return(R, Ra, Rm, Rd, Ip)
end;
```

In [222]:
```
using JuMP, Cbc

function rateModel(TMlimit, maxSalary, raw)

    N = size(raw)[1]                    # Number of players
    GKindex = find(raw[:,6].=="GK")     # Rows containing GK's
    LWindex = find(raw[:,6].=="LW")     # Rows containing LW's
    RWindex = find(raw[:,6].=="RW")     # Rows containing RW's
    STindex = find(raw[:,6].=="ST")     # Rows containing ST's
    CFindex = find(raw[:,6].=="CF")     # Rows containing CF's
    CMindex = find(raw[:,6].=="CM")     # Rows containing CM's
    LMindex = find(raw[:,6].=="LM")     # Rows containing LM's
    RMindex = find(raw[:,6].=="RM")     # Rows containing RM's
    CAMindex = find(raw[:,6].=="CAM")   # Rows containing CAM's
    CDMindex = find(raw[:,6].=="CDM")   # Rows containing CDM's
    CBindex = find(raw[:,6].=="CB")     # Rows containing CB's
    LBindex = find(raw[:,6].=="LB")     # Rows containing LB's
    RBindex = find(raw[:,6].=="RB")     # Rows containing RB's

    clubs = unique(raw[:,7])            # List of unique clubs of the players
    Num = 11                            # Total players in a team
    T = length(clubs)                   # Number of unique clubs
    minLimit = 0                        # Minimum number of player in every position (0)
    minForward = 1                      # Minimum number of forward players(including LW, RW, ST, CF)
    maxForward = 3                      # Maximum number of forward players(including LW, RW, ST, CF)
    minMid = 3                          # Minimum number of midfield players(including CM, CAM, CDM, LM, RM)
    maxMid = 5                          # Maximum number of midfield players(including CM, CAM, CDM, LM, RM)
    minBack = 2                         # Minimum number of back players(including CB, LB, RB)
    maxBack = 4                         # Maximum number of back players(including CB, LB, RB)

    # Maximum number of player in every position
    GKlimit = LWlimit = RWlimit = STlimit = CFlimit = CMlimit = CAMlimit = 1
    CDMlimit = LMlimit = RMlimit = CAMlimit =  LBlimit = RBlimit = 1
    CBlimit = 2

    m = Model(solver=CbcSolver())

    @variable(m, k[1:N], Bin)             # Indicator variable:  1- Player on team, 0- Player not on team
    @constraint(m, sum{k[i]*raw[i,2], i=1:N} <= maxSalary)          # Salary cap constraint
    @constraint(m, sum{k[i], i = GKindex} == GKlimit)               # Number of GK's constraint
    @constraint(m, minLimit <= sum{k[i], i = LWindex} <= LWlimit)   # Number of LW's constraint
```

```
    @constraint(m, minLimit <= sum{k[i], i = RWindex} <= RWlimit)    # Number of RW's constraint
    @constraint(m, minLimit <= sum{k[i], i = STindex} <= STlimit)    # Number of ST's constraint
    @constraint(m, minLimit <= sum{k[i], i = CFindex} <= CFlimit)    # Number of CF's constraint
    @constraint(m, minLimit <= sum{k[i], i = CMindex} <= CMlimit)    # Number of CM's constraint
    @constraint(m, minLimit <= sum{k[i], i = LMindex} <= LMlimit)    # Number of LM's constraint
    @constraint(m, minLimit <= sum{k[i], i = RMindex} <= RMlimit)    # Number of RM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CAMindex} <= CAMlimit)  # Number of CAM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CDMindex} <= CDMlimit)  # Number of CDM's constraint
    @constraint(m, minLimit <= sum{k[i], i = CBindex} <= CBlimit)    # Number of CB's constraint
    @constraint(m, minLimit <= sum{k[i], i = LBindex} <= LBlimit)    # Number of LB's constraint
    @constraint(m, minLimit <= sum{k[i], i = RBindex} <= RBlimit)    # Number of RB's constraint

    # Number of players(forward, midfield and back)constraint
    @constraint(m, minForward <= sum{k[i], i = [LWindex; RWindex; STindex; CFindex]} <= maxForward)
    @constraint(m, minMid <= sum{k[i], i = [CMindex; LMindex; RMindex; CAMindex; CDMindex]} <= maxMid)
    @constraint(m, minBack <= sum{k[i], i = [CBindex; LBindex; RBindex]} <= maxBack)

     # Limit amount of players from one particular team
    for t = 1:T
        teamIndex = find(raw[:,7].==clubs[t])
        @constraint(m, sum{k[i], i = teamIndex} <= TMlimit)
    end

    # Total number of players must be Num (11)
    @constraint(m, sum{k[i], i = [GKindex; LWindex; RWindex; STindex; CFindex; CMindex; LMindex; RMindex; CAMindex; CDMin
                                                  CBindex; LBindex; RBindex]} == 11)

    # Maximize the overall ability according to the value of λ
    @objective(m, Max, sum{k[i]*raw[i,1], i=1:N})

    solve(m);

    Ra = getvalue(sum(k.*raw[:,21]/Num))  # Average attack ability
    Rm = getvalue(sum(k.*raw[:,34]/Num))  # Average midfield ability
    Rd = getvalue(sum(k.*raw[:,42]/Num))  # Average defensive ability
    R = getvalue(sum(k.*raw[:,1]/Num))    # Average overall ability
    Ip = getvalue(k)                     # Indicator player vector

    return(R, Ra, Rm, Rd, Ip)
end;
```

In [223]:
```
using JuMP,DataFrames

data = "CS524-FinalProjectDatabase.csv"

raw = readcsv(data);

# Analyze data from csv file
raw = analyzeData(raw)

# Tradeoff parameter
λ = 0.6;

# Max amount of players from the same team
TMlimit = 5;

# Salary cap for the week
maxSalary = 80;
```

In [224]:
```
using JuMP, DataFrames

Num = 11        # Total players in a team

# Run attack model
(R, Ra, Rm, Rd, xopt) = attackModel(λ, TMlimit, maxSalary, raw)

# Initialize data frame containing solution
sol = DataFrame(Player = String[], Position = String[], Club = String[],
                Nation = String[], Age = Int64[], Salary = Float64[],
                Attack = Float64[], Midfield = Float64[], Defence = Float64[], Rating = Float64[])

for i = 1:length(xopt)
    if xopt[i] == 1
        # Add to dataframe if player is selected
        push!(sol, [raw[i,4] raw[i,6] raw[i,7] raw[i,9] raw[i,10] raw[i,2] raw[i,21] raw[i,34] raw[i,42] raw[i,1]])
    end
end

println("Total amounts of investment used (in million): ", sum(sol[:,6]))

# Add total row
 push!(sol, ["Average", "/", "/", "/", round(sum(sol[:,5])/Num), sum(sol[:,6])/Num, Ra,
                   Rm, Rd, sum(sol[:,10])/Num])

# Display optimal team table
sol
```

```
Total amounts of investment used (in million): 79.95299999999999
```

Out[224]:

	Player	Position	Club	Nation	Age	Salary	Attack	Midfield	Defence	Rating
1	Kevin	GK	Paris Saint-Germain	Germany	25	4.12	66.625	25.25	84.0	84.0
2	Neymar	LW	FC Barcelona	Brazil	24	11.256	91.0	76.0833	86.8571	91.0
3	George	RW	Legends	Northern Ireland	69	10.356	90.0	82.8333	74.8571	90.0
4	Robbie	ST	Legends	England	40	3.125	86.0	75.0	65.4286	86.0
5	Ruud	CM	Legends	Holland	53	8.965	85.875	90.0	81.5714	90.0
6	Stefan	CAM	Legends	Germany	47	5.356	80.75	86.0	81.2857	86.0

	Player	Position	Club	Nation	Age	Salary	Attack	Midfield	Defence	Rating
7	Lothar	CDM	Legends	Germany	54	11.354	86.5	91.0	83.8571	91.0
8	Ronaldo	CB	VfL Wolfsburg	Brazil	33	5.328	77.0	65.1667	86.0	86.0
9	Jan	CB	Tottenham Hotspur	Belgium	28	4.652	72.75	69.6667	82.0	82.0
10	Marcelo	LB	Real Madrid CF	Brazil	27	8.231	85.875	84.6667	89.0	89.0
11	Xherdan	RM	Stoke City	Switzerland	24	7.21	86.75	82.0	71.1429	82.0
12	Average	/	/	/	39	7.26845	82.6477	75.2424	80.5455	87.0

In [225]:
```
using JuMP, DataFrames

Num = 11        # Total players in a team

# Run midfield model
(R, Ra, Rm, Rd, xopt) = midfieldModel(λ, TMlimit, maxSalary, raw)

# Initialize data frame containing solution
sol = DataFrame(Player = String[], Position = String[], Club = String[],
                Nation = String[], Age = Int64[], Salary = Float64[],
                Attack = Float64[], Midfield = Float64[], Defence = Float64[], Rating = Float64[])

for i = 1:length(xopt)
    if xopt[i] == 1
        # Add to dataframe if player is selected
        push!(sol, [raw[i,4] raw[i,6] raw[i,7] raw[i,9] raw[i,10] raw[i,2] raw[i,21] raw[i,34] raw[i,42] raw[i,1]])
    end
end

println("Total amounts of investment used (in million): ", sum(sol[:,6]))

# Add total row
 push!(sol, ["Average", "/", "/", "/", round(sum(sol[:,5])/Num), sum(sol[:,6])/Num, sum(sol[:,7])/Num,
                   sum(sol[:,8])/Num, sum(sol[:,9])/Num, sum(sol[:,10])/Num])

# Display optimal team table
sol
```

```
Total amounts of investment used (in million): 79.919
```

Out[225]:

	Player	Position	Club	Nation	Age	Salary	Attack	Midfield	Defence	Rating
1	Jens	GK	Legends	Germany	46	8.487	66.25	38.25	88.0	88.0
2	Nicola	LW	Sassuolo	Italy	24	2.144	75.0	91.75	61.4286	75.0
3	George	RW	Legends	Northern Ireland	69	10.356	90.0	82.8333	74.8571	90.0
4	Wayne	ST	Manchester United	England	30	6.147	87.0	81.9167	70.5714	87.0
5	Arturo	CM	FC Bayern Munich	Chile	28	6.121	80.375	86.0	84.7143	86.0
6	Stefan	CAM	Legends	Germany	47	5.356	80.75	86.0	81.2857	86.0

	Player	Position	Club	Nation	Age	Salary	Attack	Midfield	Defence	Rating
7	Lothar	CDM	Legends	Germany	54	11.354	86.5	91.0	83.8571	91.0
8	Diego	CB	Atl??tico Madrid	Uruguay	29	7.654	71.5	72.9167	89.0	89.0
9	Frank	CB	Legends	Holland	45	6.215	69.375	73.5833	86.0	86.0
10	Marcelo	LB	Real Madrid CF	Brazil	27	8.231	85.875	84.6667	89.0	89.0
11	Gareth	RM	Real Madrid CF	Wales	26	7.854	88.5	87.0	71.2857	87.0
12	Average	/	/	/	39	7.26536	80.1023	79.6288	80.0	86.7273

In [226]:
```
using JuMP, DataFrames

Num = 11        # Total players in a team

# Run defend model
(R, Ra, Rm, Rd, xopt) = defendModel(λ, TMlimit, maxSalary, raw)

# Initialize data frame containing solution
sol = DataFrame(Player = String[], Position = String[], Club = String[],
                Nation = String[], Age = Int64[], Salary = Float64[],
                Attack = Float64[], Midfield = Float64[], Defence = Float64[], Rating = Float64[])

for i = 1:length(xopt)
    if xopt[i] == 1
        # Add to dataframe if player is selected
        push!(sol, [raw[i,4] raw[i,6] raw[i,7] raw[i,9] raw[i,10] raw[i,2] raw[i,21] raw[i,34] raw[i,42] raw[i,1]])
    end
end

println("Total amounts of investment used (in million): ", sum(sol[:,6]))

# Add total row
 push!(sol, ["Average", "/", "/", "/", round(sum(sol[:,5])/Num), sum(sol[:,6])/Num, sum(sol[:,7])/Num,
                   sum(sol[:,8])/Num, sum(sol[:,9])/Num, sum(sol[:,10])/Num])

# Display optimal team table
sol
```

```
Total amounts of investment used (in million): 79.77999999999999
```

Out[226]:

	Player	Position	Club	Nation	Age	Salary	Attack	Midfield	Defence	Rating
1	Jens	GK	Legends	Germany	46	8.487	66.25	38.25	88.0	88.0
2	Neymar	LW	FC Barcelona	Brazil	24	11.256	91.0	76.0833	86.8571	91.0
3	Henrikh	RW	Borussia Dortmund	Armenia	27	7.458	82.0	75.6667	75.8571	82.0
4	Wayne	ST	Manchester United	England	30	6.147	87.0	81.9167	70.5714	87.0
5	Arturo	CM	FC Bayern Munich	Chile	28	6.121	80.375	86.0	84.7143	86.0
6	Stefan	CAM	Legends	Germany	47	5.356	80.75	86.0	81.2857	86.0

	Player	Position	Club	Nation	Age	Salary	Attack	Midfield	Defence	Rating
7	Nemanja	CDM	Chelsea	Serbia	27	5.654	72.875	84.0	83.8571	84.0
8	Franz	CB	Legends	Germany	70	12.523	80.0	79.9167	93.0	93.0
9	Frank	CB	Legends	Holland	45	6.215	69.375	73.5833	86.0	86.0
10	Marcelo	LB	Real Madrid CF	Brazil	27	8.231	85.875	84.6667	89.0	89.0
11	Eden??lson	RM	Udinese	Brazil	26	2.332	75.375	75.0	71.1429	75.0
12	Average	/	/	/	36	7.25273	79.1705	76.4621	82.7532	86.0909

In [227]:
```
using JuMP, DataFrames

Num = 11        # Total players in a team

# Run rate model
(R, Ra, Rm, Rd, xopt) = rateModel(TMlimit, maxSalary, raw)

# Initialize data frame containing solution
sol = DataFrame(Player = String[], Position = String[], Club = String[],
                Nation = String[], Age = Int64[], Salary = Float64[],
                Attack = Float64[], Midfield = Float64[], Defence = Float64[], Rating = Float64[])

for i = 1:length(xopt)
    if xopt[i] == 1
        # Add to dataframe if player is selected
        push!(sol, [raw[i,4] raw[i,6] raw[i,7] raw[i,9] raw[i,10] raw[i,2] raw[i,21] raw[i,34] raw[i,42] raw[i,1]])
    end
end

println("Total amounts of investment used (in million): ", sum(sol[:,6]))

# Add total row
 push!(sol, ["Average", "/", "/", "/", round(sum(sol[:,5])/Num), sum(sol[:,6])/Num, sum(sol[:,7])/Num,
                   sum(sol[:,8])/Num, sum(sol[:,9])/Num, sum(sol[:,10])/Num])

# Display optimal team table
sol
```

```
Total amounts of investment used (in million): 79.92199999999998
```

Out[227]:

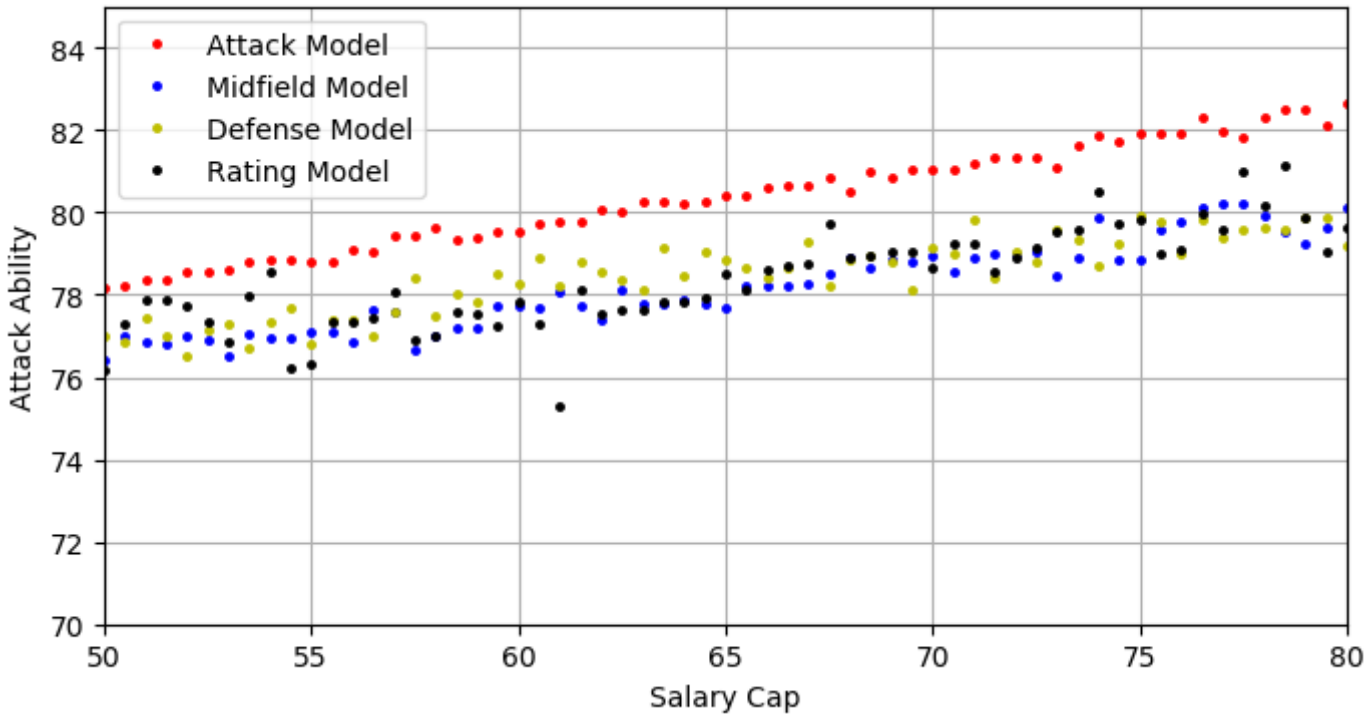
	Player	Position	Club	Nation	Age	Salary	Attack	Midfield	Defence	Rating
1	St??phane	GK	AS Saint-??tienne	France	29	3.586	60.0	24.6667	84.0	84.0
2	C. Ronaldo	LW	Real Madrid CF	Portugal	31	14.654	96.0	81.0	56.2857	96.0
3	Robbie	ST	Legends	England	40	3.125	86.0	75.0	65.4286	86.0
4	Kevin	CM	Manchester City	Belgium	24	6.322	82.75	87.0	62.0	87.0
5	Dennis	CF	Legends	Holland	46	10.025	90.0	77.3333	53.8571	90.0
6	Stefan	CAM	Legends	Germany	47	5.356	80.75	86.0	81.2857	86.0

	Player	Position	Club	Nation	Age	Salary	Attack	Midfield	Defence	Rating
7	Sergio	CDM	FC Barcelona	Spain	27	6.354	61.375	86.0	79.7143	86.0
8	Diego	CB	Atl??tico Madrid	Uruguay	29	7.654	71.5	72.9167	89.0	89.0
9	J??r??me	CB	FC Bayern Munich	Germany	27	5.958	71.75	65.5	87.0	87.0
10	Marcelo	LB	Real Madrid CF	Brazil	27	8.231	85.875	84.6667	89.0	89.0
11	Arjen	RM	FC Bayern Munich	Holland	32	8.657	90.125	90.0	51.8571	90.0
12	Average	/	/	/	33	7.26564	79.6477	75.4621	72.6753	88.1818

In [231]:
```
using JuMP, DataFrames, PyPlot

Num = 11        # Total players in a team

figure(figsize=(8,4))
for maxSalary = 50:0.5:80
    (R1, Ra1, Rm1, Rd1, xopt1) = attackModel(λ, TMlimit, maxSalary, raw)
    (R2, Ra2, Rm2, Rd2, xopt2) = midfieldModel(λ, TMlimit, maxSalary, raw)
    (R3, Ra3, Rm3, Rd3, xopt3) = defendModel(λ, TMlimit, maxSalary, raw)
    (R4, Ra4, Rm4, Rd4, xopt4) = rateModel(TMlimit, maxSalary, raw)
    plot(maxSalary, Ra1,"r.", markersize=5)
    plot(maxSalary, Ra2,"b.", markersize=5)
    plot(maxSalary, Ra3,"y.", markersize=5)
    plot(maxSalary, Ra4,"k.", markersize=5)
end
axis([50,80,70,85])
grid("on")
ylabel("Attack Ability")
xlabel("Salary Cap")
legend(["Attack Model", "Midfield Model", "Defense Model", "Rating Model"])
```

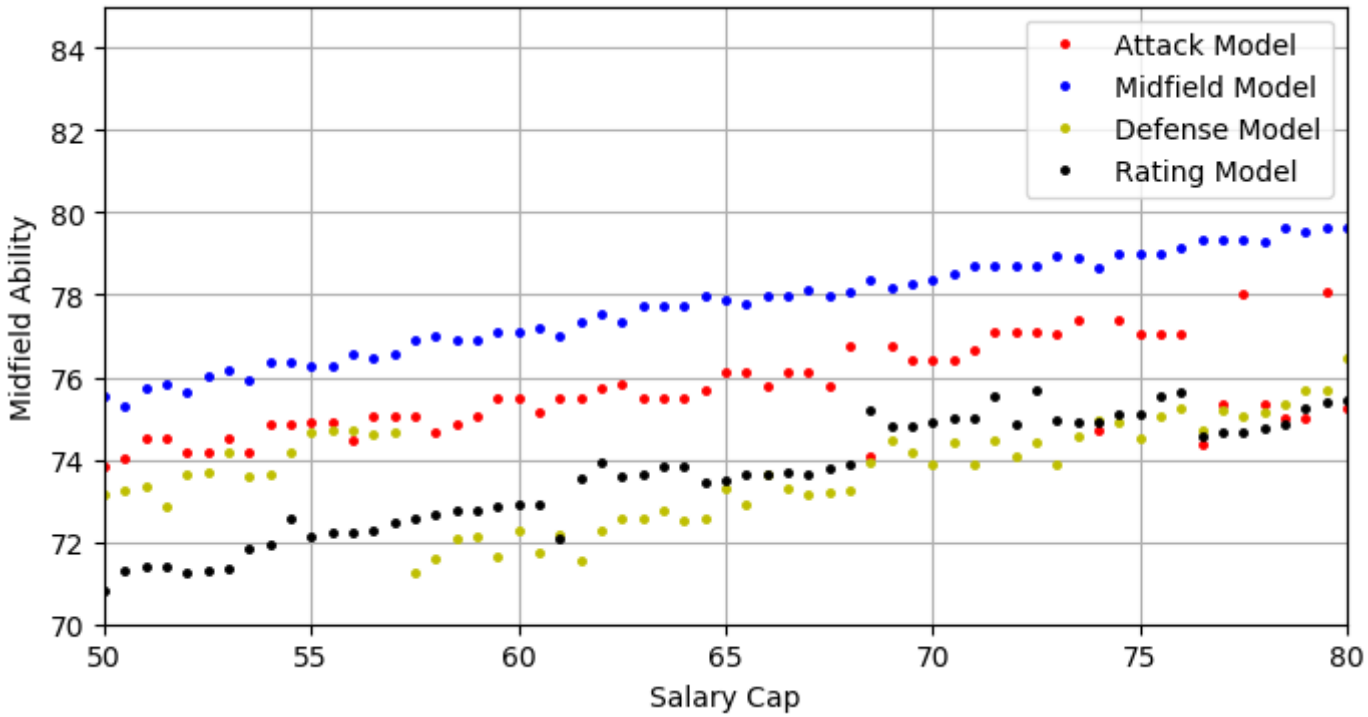


Out[231]: PyObject <matplotlib.legend.Legend object at 0x000000005605B438>

In [233]:
```
using JuMP, DataFrames, PyPlot

Num = 11        # Total players in a team

figure(figsize=(8,4))
for maxSalary = 50:0.5:80
    (R1, Ra1, Rm1, Rd1, xopt1) = attackModel(λ, TMlimit, maxSalary, raw)
    (R2, Ra2, Rm2, Rd2, xopt2) = midfieldModel(λ, TMlimit, maxSalary, raw)
    (R3, Ra3, Rm3, Rd3, xopt3) = defendModel(λ, TMlimit, maxSalary, raw)
    (R4, Ra4, Rm4, Rd4, xopt4) = rateModel(TMlimit, maxSalary, raw)
    plot(maxSalary, Rm1,"r.", markersize=5)
    plot(maxSalary, Rm2,"b.", markersize=5)
    plot(maxSalary, Rm3,"y.", markersize=5)
    plot(maxSalary, Rm4,"k.", markersize=5)
end
axis([50,80,70,85])
grid("on")
ylabel("Midfield Ability")
xlabel("Salary Cap")
legend(["Attack Model", "Midfield Model", "Defense Model", "Rating Model"])
```

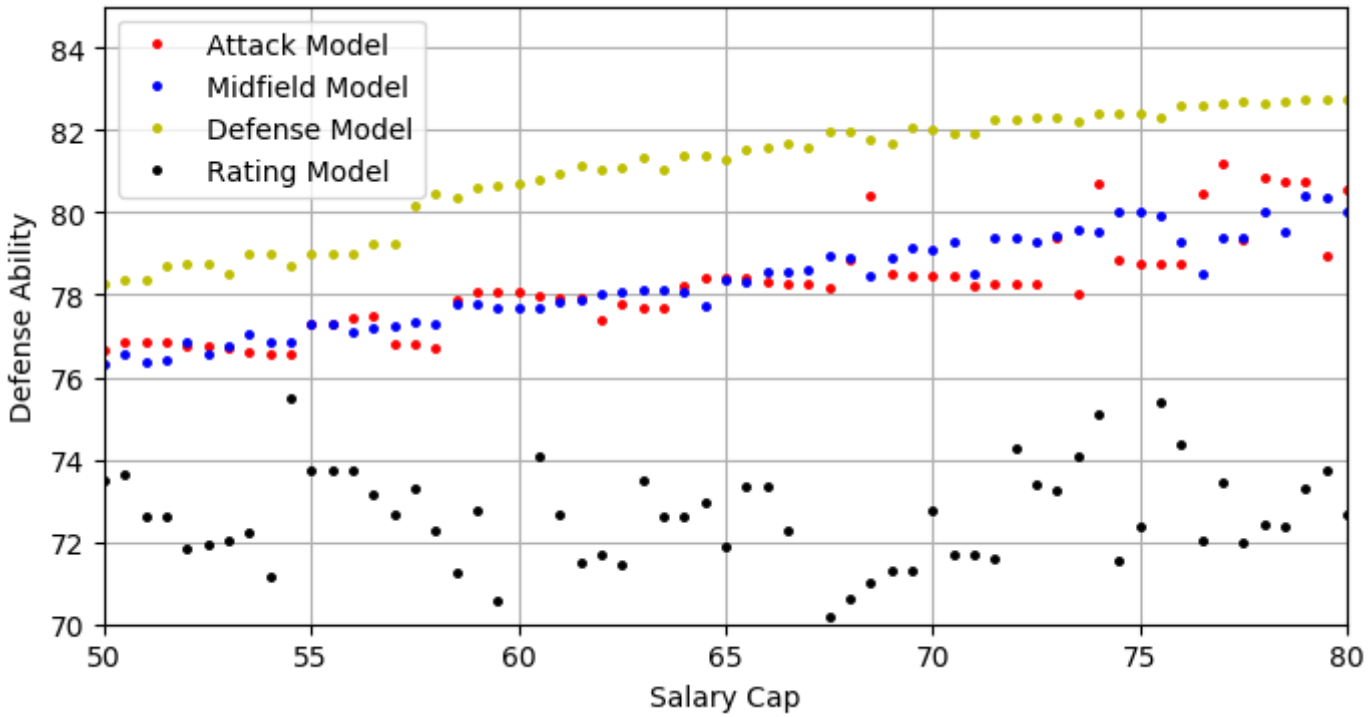


Out[233]: PyObject <matplotlib.legend.Legend object at 0x0000000006248A908>

In [234]:
```
using JuMP, DataFrames, PyPlot

Num = 11        # Total players in a team

figure(figsize=(8,4))
for maxSalary = 50:0.5:80
    (R1, Ra1, Rm1, Rd1, xopt1) = attackModel(λ, TMlimit, maxSalary, raw)
    (R2, Ra2, Rm2, Rd2, xopt2) = midfieldModel(λ, TMlimit, maxSalary, raw)
    (R3, Ra3, Rm3, Rd3, xopt3) = defendModel(λ, TMlimit, maxSalary, raw)
    (R4, Ra4, Rm4, Rd4, xopt4) = rateModel(TMlimit, maxSalary, raw)
    plot(maxSalary, Rd1,"r.", markersize=5)
    plot(maxSalary, Rd2,"b.", markersize=5)
    plot(maxSalary, Rd3,"y.", markersize=5)
    plot(maxSalary, Rd4,"k.", markersize=5)
end
axis([50,80,70,85])
grid("on")
ylabel("Defense Ability")
xlabel("Salary Cap")
legend(["Attack Model", "Midfield Model", "Defense Model", "Rating Model"])
```



Out[234]: PyObject <matplotlib.legend.Legend object at 0x00000000624B6CF8>

In [ ]: