

# FOOTBALL ANALYSIS USING THE MARKOV CHAIN PROCESS (A CASE STUDY OF FC BARCELONA VS REAL MADRID FC)

**ABSTRACT:** Markov Chain Analysis, a case study of FC Barcelona vs Real Madrid FC was performed. Some important cases of this research such as the Primera Division (La Liga), Copa Del Rey, SuperCopa De Espana and the Champions League have been statistically studied. We studied when both Football clubs are at home and at away and their probabilities/chances of winning, drawing and losing a match. We also studied the possibility/chances of their matches producing over/under 1.5goals and over/under 2.5 goals. We studied the probability/chance of winning, drawing or losing two consecutive matches, and winning-drawing, winning-losing, drawing-winning, drawing-losing, losing-winning, and losing-drawing two straight matches. We found out from our study that FC Barcelona did well/better in the Copa Del Rey Cup and the Champions League competitions, while Real Madrid FC did better/well in Primera Division (La Liga) and the SuperCopa De Espana competitions, we also found out that their matches have high chances of playing over 1.5 and over 2.5.

**Keywords:** Markov Chain Analysis, FC Barcelona, Real Madrid FC, Chances, Probability, Winning, Drawing, Losing, Over/Under 1.5, Over/Under 2.5, Matches, Transition, Matrix, Transition Diagram.

## INTRODUCTION

In recent years, football analysis has become a more interesting area of data analysis as many sports companies such as Genius sports, Stat Bomb, Stats Perform etc. have queued into football analysis to provide a more reliable football all data (information) to Betting Companies, Football Clubs, Bookmakers and to the fans out there.

This study involves the use of Markov Chain Analysis (Process) to perform a Football analysis on FC Barcelona against Real Madrid FC both at home and away .

## PRIMERA DIVISION RESULTS

1929/1929

FC Barcelona **1-2** Real Madrid FC

Real Madrid FC **0-1** FC Barcelona

1930/1930

FC Barcelona **1-4** Real Madrid FC

Real Madrid FC **5-1** FC Barcelona

1931/1931

Real Madrid FC **0-0** FC Barcelona

FC Barcelona **3-1** Real Madrid FC

1932/1932

Real Madrid FC **2-0** FC Barcelona

FC Barcelona **2-2** Real Madrid FC

1933/1933

FC Barcelona **1-1** Real Madrid FC

Real Madrid FC **2-1** FC Barcelona

1933/1934

FC Barcelona **1-2** Real Madrid FC

Real Madrid FC **4-0** FC Barcelona

1935/1935

Real Madrid FC **8-2** FC Barcelona

FC Barcelona **5-0** Real Madrid FC

1935/1936

FC Barcelona **3-0** Real Madrid FC

Real Madrid FC **3-0** FC Barcelona

1940/1940

Real Madrid FC **2-1** FC Barcelona

FC Barcelona **0-0** Real Madrid FC

1940/1941

FC Barcelona **3-0** Real Madrid FC

Real Madrid FC **1-2** FC Barcelona

1941/1942

Real Madrid FC **4-3** FC Barcelona

FC Barcelona **0-2** Real Madrid FC

1942/1943

Real Madrid FC **3-0** FC Barcelona

FC Barcelona **5-5** Real Madrid FC

1944/1944

Real Madrid FC **0-1** FC Barcelona

FC Barcelona **1-2** Real Madrid FC

1944/1945

Real Madrid FC **1-0** FC Barcelona

FC Barcelona **5-0** Real Madrid FC

1945/1946

Real Madrid FC **3-2** FC Barcelona

FC Barcelona **1-0** Real Madrid FC

1946/1947

Real Madrid FC **2-1** FC Barcelona

FC Barcelona **3-2** Real Madrid FC

1947/1948

Real Madrid FC **1-1** FC Barcelona

FC Barcelona **4-2** Real Madrid FC

1948/1949

Real Madrid FC **1-2** FC Barcelona

FC Barcelona **3-1** Real Madrid FC

1944/1944

Real Madrid FC **0-1** FC Barcelona  
FC Barcelona **1-2** Real Madrid FC  
1949/1950

Real Madrid FC **6-1** FC Barcelona  
FC Barcelona **2-3** Real Madrid FC  
1950/1951

FC Barcelona **7-2** Real Madrid FC  
Real Madrid FC **4-1** FC Barcelona  
1951/1952

Real Madrid FC **5-1** FC Barcelona  
FC Barcelona **4-2** Real Madrid FC  
1952/1953

Real Madrid FC **2-1** FC Barcelona  
FC Barcelona **1-0** Real Madrid FC  
1953/1954

Real Madrid FC **5-0** FC Barcelona  
FC Barcelona **5-1** Real Madrid FC  
1954/1955

Real Madrid FC **3-0** FC Barcelona  
FC Barcelona **2-2** Real Madrid FC  
1955/1956

Real Madrid FC **2-1** FC Barcelona  
FC Barcelona **2-0** Real Madrid FC  
1956/1957

FC Barcelona **1-0** Real Madrid FC  
Real Madrid FC **1-0** FC Barcelona  
1957/1958

Real Madrid FC **3-0** FC Barcelona  
FC Barcelona **0-2** Real Madrid FC

1958/1959

FC Barcelona **4-0** Real Madrid FC  
Real Madrid FC **1-0** FC Barcelona

1959/1960

Real Madrid FC **2-0** FC Barcelona  
FC Barcelona **3-1** Real Madrid FC

1960/1961

FC Barcelona **3-5** Real Madrid FC  
Real Madrid FC **3-2** FC Barcelona

1961/1962

Real Madrid FC **2-0** FC Barcelona  
FC Barcelona **3-1** Real Madrid FC

1962/1963

Real Madrid FC **2-0** FC Barcelona  
FC Barcelona **1-5** Real Madrid FC

1963/1964

Real Madrid FC **4-0** FC Barcelona  
FC Barcelona **1-2** Real Madrid FC

1964/1965

Real Madrid FC **4-1** FC Barcelona  
FC Barcelona **1-2** Real Madrid FC

1965/1966

Real Madrid FC **1-3** FC Barcelona  
FC Barcelona **2-1** Real Madrid FC

1966/1967

Real Madrid FC **1-0** FC Barcelona  
FC Barcelona **2-1** Real Madrid FC

1967/1968

Real Madrid FC **1-1** FC Barcelona  
FC Barcelona **1-1** Real Madrid FC

1968/1969

Real Madrid FC **2-1** FC Barcelona  
FC Barcelona **1-1** Real Madrid FC

1969/1969

Real Madrid FC **3-3** FC Barcelona  
FC Barcelona **1-0** Real Madrid FC

1970/1971

Real Madrid FC **0-1** FC Barcelona  
FC Barcelona **0-1** Real Madrid FC

1971/1972

Real Madrid FC **1-1** FC Barcelona  
FC Barcelona **1-0** Real Madrid FC

1971/1973

FC Barcelona **1-0** Real Madrid FC  
Real Madrid FC **0-0** FC Barcelona

1973/1974

FC Barcelona **0-0** Real Madrid FC  
Real Madrid FC **0-5** FC Barcelona

1975/1975

Real Madrid FC **1-0** FC Barcelona  
FC Barcelona **0-0** Real Madrid FC

1975/1976

FC Barcelona **2-1** Real Madrid FC  
Real Madrid FC **0-2** FC Barcelona

1976/1977

FC Barcelona **3-1** Real Madrid FC  
Real Madrid FC **1-1** FC Barcelona

1977/1978

FC Barcelona **2-3** Real Madrid FC  
Real Madrid FC **4-0** FC Barcelona

1978/1979

Real Madrid FC **3-1** FC Barcelona  
FC Barcelona **2-0** Real Madrid FC

1979/1980

Real Madrid FC **3-2** FC Barcelona  
FC Barcelona **0-2** Real Madrid FC

1980/1981

FC Barcelona **2-1** Real Madrid FC  
Real Madrid FC **3-0** FC Barcelona

1981/1982

FC Barcelona **3-1** Real Madrid FC  
Real Madrid FC **3-1** FC Barcelona

1982/1983

Real Madrid FC **0-2** FC Barcelona  
FC Barcelona **2-1** Real Madrid FC

1983/1984

FC Barcelona **1-2** Real Madrid FC  
Real Madrid FC **2-1** FC Barcelona

1984/1984

Real Madrid FC **0-3** FC Barcelona  
FC Barcelona **3-2** Real Madrid FC

1985/1986

FC Barcelona **2-0** Real Madrid FC  
Real Madrid FC **3-1** FC Barcelona

1986/1987

Real Madrid FC **1-1** FC Barcelona  
FC Barcelona **3-2** Real Madrid FC

1987/1987

Real Madrid FC **0-0** FC Barcelona  
FC Barcelona **2-1** Real Madrid FC

1988/1988

Real Madrid FC **2-1** FC Barcelona  
FC Barcelona **2-0** Real Madrid FC

1988/1989

Real Madrid FC **3-2** FC Barcelona  
FC Barcelona **0-0** Real Madrid FC

1989/1990

FC Barcelona **3-1** Real Madrid FC  
Real Madrid FC **3-2** FC Barcelona

1990/1991

FC Barcelona **2-1** Real Madrid FC  
Real Madrid FC **1-0** FC Barcelona

1991/1992

Real Madrid FC **1-1** FC Barcelona  
FC Barcelona **1-1** Real Madrid FC

1992/1993

FC Barcelona **2-1** Real Madrid FC  
Real Madrid FC **2-1** FC Barcelona

1994/1994

FC Barcelona **5-0** Real Madrid FC  
Real Madrid FC **0-1** FC Barcelona

1995/1995

Real Madrid FC **5-0** FC Barcelona  
FC Barcelona **1-0** Real Madrid FC

1995/1996

Real Madrid FC **1-1** FC Barcelona  
FC Barcelona **3-0** Real Madrid FC

1996/1997

Real Madrid FC **2-0** FC Barcelona  
FC Barcelona **1-0** Real Madrid FC

1997/1998

Real Madrid FC **2-3** FC Barcelona  
FC Barcelona **3-0** Real Madrid FC

1998/1999

Real Madrid FC **2-2** FC Barcelona  
FC Barcelona **3-0** Real Madrid FC

1999/2000

FC Barcelona **2-2** Real Madrid FC  
Real Madrid FC **3-0** FC Barcelona

2000/2001

FC Barcelona **2-0** Real Madrid FC  
Real Madrid FC **2-2** FC Barcelona

2001/2002

Real Madrid FC **2-0** FC Barcelona  
FC Barcelona **1-1** Real Madrid FC

2002/2003

FC Barcelona **0-0** Real Madrid FC  
Real Madrid FC **1-1** FC Barcelona

2003/2004

FC Barcelona **1-2** Real Madrid FC  
Real Madrid FC **1-2** FC Barcelona

2004/2005

FC Barcelona **3-0** Real Madrid FC  
Real Madrid FC **4-2** FC Barcelona

2005/2006

Real Madrid FC **0-3** FC Barcelona  
FC Barcelona **1-1** Real Madrid FC

2006/2007

Real Madrid FC **2-0** FC Barcelona  
FC Barcelona **3-3** Real Madrid FC

2007/2008

FC Barcelona **0-1** Real Madrid FC

Real Madrid FC **4-1** FC Barcelona

2008/2009

FC Barcelona **2-0** Real Madrid FC

Real Madrid FC **2-6** FC Barcelona

2009/2010

FC Barcelona **1-0** Real Madrid FC

Real Madrid FC **0-2** FC Barcelona

2010/2011

FC Barcelona **5-0** Real Madrid FC

Real Madrid FC **1-1** FC Barcelona

2011/2012

Real Madrid FC **1-3** FC Barcelona

FC Barcelona **1-2** Real Madrid FC

2012/2013

FC Barcelona **2-2** Real Madrid FC

Real Madrid FC **2-1** FC Barcelona

2013/2014

FC Barcelona **2-1** Real Madrid FC

Real Madrid FC **3-4** FC Barcelona

2014/2015

Real Madrid FC **3-1** FC Barcelona

FC Barcelona **2-1** Real Madrid FC

2015/2016

Real Madrid FC **0-4** FC Barcelona

FC Barcelona **1-2** Real Madrid FC

2016/2017

FC Barcelona **1-1** Real Madrid FC

Real Madrid FC **2-3** FC Barcelona

2017/2018

Real Madrid FC **0-3** FC Barcelona

FC Barcelona **2-2** Real Madrid FC

2018/2019

FC Barcelona **5-1** Real Madrid FC

Real Madrid FC **0-1** FC Barcelona

2019/2020

FC Barcelona **0-0** Real Madrid FC

Real Madrid FC **2-0** FC Barcelona

2020/2021

Real Madrid FC **2-0** FC Barcelona

FC Barcelona **1-3** Real Madrid F

## FC BARCELONA AT HOME

1929/1929

FC Barcelona **1-2** Real Madrid FC

1930/1930

FC Barcelona **1-4** Real Madrid FC

1931/1931

FC Barcelona **3-1** Real Madrid FC

1932/1932

FC Barcelona **2-2** Real Madrid FC

1933/1933

FC Barcelona **1-1** Real Madrid FC

1933/1934  
FC Barcelona **1-2** Real Madrid FC  
1935/1935  
FC Barcelona **5-0** Real Madrid FC  
1935/1936  
FC Barcelona **3-0** Real Madrid FC  
1940/1940  
FC Barcelona **0-0** Real Madrid FC  
1940/1941  
FC Barcelona **3-0** Real Madrid FC  
1941/1942  
FC Barcelona **0-2** Real Madrid FC  
1942/1943  
FC Barcelona **5-5** Real Madrid FC  
1944/1944  
FC Barcelona **1-2** Real Madrid FC  
1944/1945  
FC Barcelona **5-0** Real Madrid FC  
1945/1946  
FC Barcelona **1-0** Real Madrid FC  
1946/1947  
FC Barcelona **3-2** Real Madrid FC  
1947/1948  
FC Barcelona **4-2** Real Madrid FC  
1948/1949  
FC Barcelona **3-1** Real Madrid FC  
1944/1944  
FC Barcelona **1-2** Real Madrid FC  
1949/1950  
FC Barcelona **2-3** Real Madrid FC

1950/1951  
FC Barcelona **7-2** Real Madrid FC  
1951/1952  
FC Barcelona **4-2** Real Madrid FC  
1952/1953  
FC Barcelona **1-0** Real Madrid FC  
1953/1954  
FC Barcelona **5-1** Real Madrid FC  
1954/1955  
FC Barcelona **2-2** Real Madrid FC  
1955/1956  
FC Barcelona **2-0** Real Madrid FC  
1956/1957  
FC Barcelona **1-0** Real Madrid FC  
1957/1958  
FC Barcelona **0-2** Real Madrid FC  
1958/1959  
FC Barcelona **4-0** Real Madrid FC  
1959/1960  
FC Barcelona **3-1** Real Madrid FC  
1960/1961  
FC Barcelona **3-5** Real Madrid FC  
1961/1962  
FC Barcelona **3-1** Real Madrid FC  
1962/1963  
FC Barcelona **1-5** Real Madrid FC  
1963/1964  
FC Barcelona **1-2** Real Madrid FC  
1964/1965

FC Barcelona **1-2** Real Madrid FC  
1965/1966

FC Barcelona **2-1** Real Madrid FC  
1966/1967

FC Barcelona **2-1** Real Madrid FC  
1967/1968

FC Barcelona **1-1** Real Madrid FC  
1968/1969

FC Barcelona **1-1** Real Madrid FC  
1969/1969

FC Barcelona **1-0** Real Madrid FC  
1970/1971

FC Barcelona **0-1** Real Madrid FC  
1971/1972

FC Barcelona **1-0** Real Madrid FC  
1971/1973

FC Barcelona **1-0** Real Madrid FC  
1973/1974

FC Barcelona **0-0** Real Madrid FC  
Real Madrid FC **0-5** FC Barcelona  
1975/1975

Real Madrid FC **1-0** FC Barcelona

FC Barcelona **0-0** Real Madrid FC  
1975/1976

FC Barcelona **2-1** Real Madrid FC  
1976/1977

FC Barcelona **3-1** Real Madrid FC  
1977/1978

FC Barcelona **2-3** Real Madrid FC  
1978/1979

FC Barcelona **2-0** Real Madrid FC  
1979/1980

FC Barcelona **0-2** Real Madrid FC  
1980/1981

FC Barcelona **2-1** Real Madrid FC  
1981/1982

FC Barcelona **3-1** Real Madrid FC  
1982/1983

FC Barcelona **2-1** Real Madrid FC  
1983/1984

FC Barcelona **1-2** Real Madrid FC  
1984/1984

FC Barcelona **3-2** Real Madrid FC  
1985/1986

FC Barcelona **2-0** Real Madrid FC  
1986/1987

FC Barcelona **3-2** Real Madrid FC  
1987/1987

FC Barcelona **2-1** Real Madrid FC  
1988/1988

FC Barcelona **2-0** Real Madrid FC  
1988/1989

FC Barcelona **0-0** Real Madrid FC  
1989/1990

FC Barcelona **3-1** Real Madrid FC  
1990/1991

FC Barcelona **2-1** Real Madrid FC  
1991/1992

FC Barcelona **1-1** Real Madrid FC  
1992/1993



FC Barcelona **2-1** Real Madrid FC

1994/1994

FC Barcelona **5-0** Real Madrid FC

1995/1995

FC Barcelona **1-0** Real Madrid FC

1995/1996

FC Barcelona **3-0** Real Madrid FC

1996/199

FC Barcelona **1-0** Real Madrid FC

1997/1998

FC Barcelona **3-0** Real Madrid FC

1998/1999

FC Barcelona **3-0** Real Madrid FC

1999/2000

FC Barcelona **2-2** Real Madrid FC

2000/2001

FC Barcelona **2-0** Real Madrid FC

2001/2002

FC Barcelona **1-1** Real Madrid FC

2002/2003

FC Barcelona **0-0** Real Madrid FC

2003/2004

FC Barcelona **1-2** Real Madrid FC

2004/2005

FC Barcelona **3-0** Real Madrid FC

2005/2006

FC Barcelona **1-1** Real Madrid FC

2006/2007

FC Barcelona **3-3** Real Madrid FC

2007/2008

FC Barcelona **0-1** Real Madrid FC

2008/2009

FC Barcelona **2-0** Real Madrid FC

2009/2010

FC Barcelona **1-0** Real Madrid FC

2010/2011

FC Barcelona **5-0** Real Madrid FC

2011/2012

FC Barcelona **1-2** Real Madrid FC

2012/2013

FC Barcelona **2-2** Real Madrid FC

2013/2014

FC Barcelona **2-1** Real Madrid FC

2014/2015

FC Barcelona **2-1** Real Madrid FC

2015/2016

FC Barcelona **1-2** Real Madrid FC

2016/2017

FC Barcelona **1-1** Real Madrid FC

2017/2018

FC Barcelona **2-2** Real Madrid FC

2018/2019

FC Barcelona **5-1** Real Madrid FC

2019/2020

FC Barcelona **0-0** Real Madrid FC

2020/2021

FC Barcelona **1-3** Real Madrid FC

## THE TRANSITION MATRIX FOR BARCELONA FC AT HOME WITH REAL MADRID FC

### DATA

L L W D D L W L D W L D L W W W W W L W W W W D W W L W W L  
W L L L W W D D W L W W D D W W L W L W W W L W W W W D W  
W D W W W W W W D W D D L W D D L W W W L D W W L D D W D L

Number of Wins = 50

Number of Draws = 20

Number of Losses = 21

Total number of matches played = 91

### Matrix

$$p = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} WW & WD & WL \\ DW & DD & DL \\ LW & LD & LL \end{pmatrix} \end{matrix}$$

Where

W denotes Win

D denotes Draw

L denotes Loss

$$p = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 28 & 10 & 12 \\ 9 & 6 & 5 \\ 13 & 4 & 3 \end{pmatrix} \end{matrix}$$

### LOADING THE REQUIRED LIBRARIES

```
library(markovchain)
```

```
Package: markovchain
```

```
Version: 0.8.9
```

```
Date: 2022-05-24
```

```
BugReport: https://github.com/spedygiorgio/markovchain/issues
```

```
library(diagram)
```

```
Loading required package: shape
```

## STATES

```
states <- c("W", "D", "L")
```

$$p_{ij} = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 28/50 & 10/50 & 12/50 \\ 9/20 & 6/20 & 5/20 \\ 13/20 & 4/20 & 5/20 \end{pmatrix} \end{matrix}$$

## PROBABILITY TRANSITIONAL MATRIX

```
BH <- matrix(c(0.56, 0.20, 0.24, 0.45, 0.30, 0.25, 0.65, 0.20, 0.15),  
            nrow = 3, byrow = T, dimnames = list(states, states))
```

BH

$$p_{ij} = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 0.56 & 0.20 & 0.24 \\ 0.45 & 0.30 & 0.25 \\ 0.65 & 0.20 & 0.15 \end{pmatrix} \end{matrix}$$

```
Bh.laliga<- new("markovchain", states = states, byrow = T, transitionMatrix =  
BH, name = "FC Barcelona At Home La Liga")
```

Bh.laliga

FC Barcelona At Home La Liga

A 3 - dimensional discrete Markov Chain defined by the following states:

W, D, L

The transition matrix (by rows) is defined as follows:

$$p_{ij} = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 0.56 & 0.20 & 0.24 \\ 0.45 & 0.30 & 0.25 \\ 0.65 & 0.20 & 0.15 \end{pmatrix} \end{matrix}$$

## PROBABILITY OF PLAYING TWO CONSECUTIVE MATCHES

```
transitionProbability(Bh.laliga, "W", "W")
```

```
[1] 0.56
```

```

transitionProbability(Bh.laliga,"W","D")
[1] 0.2
transitionProbability(Bh.laliga,"W","L")
[1] 0.24
transitionProbability(Bh.laliga,"D","W")
[1] 0.45
transitionProbability(Bh.laliga,"D","D")
[1] 0.3
transitionProbability(Bh.laliga,"D","L")
[1] 0.25
transitionProbability(Bh.laliga,"L","W")
[1] 0.65
transitionProbability(Bh.laliga,"L","D")
[1] 0.2
transitionProbability(Bh.laliga,"L","L")
[1] 0.15

```

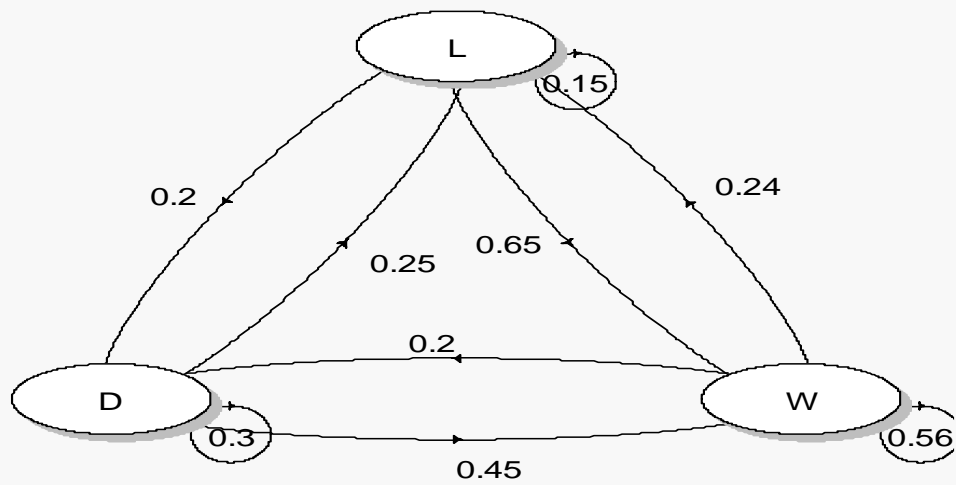
## THE STEADY STATE/LONG RUN PROBABILITY

```

steadyStates(Bh.laliga)
      W      D      L
[1,] 0.5555556 0.2222222 0.2222222
round(steadyStates(Bh.laliga),2)
      W      D      L
[1,] 0.56 0.22 0.22

```

**Transition Diagram Of Barcelona FC At Home**



### INTERPRETATION

Our research shows that FC Barcelona has a 56% chance of winning, 22% of drawing and 22% of losing when playing at home to Real Madrid FC in the Primera Division (La Liga) games. Also, FC Barcelona has 56% chances of winning two consecutive matches, 30% chances of drawing two consecutive matches, 15% chances of losing two consecutive matches, 20% chances of winning-drawing two straight matches, 24% chances of winning-losing two straight matches, 45% chances of drawing-winning two straight matches, 25% chances of drawing-losing two straight matches, 65% chances of losing-winning two straight matches, and 20% chances of losing-drawing two straight matches when playing at home to Real Madrid FC in the Primera Division (La Liga) games. Above is the Transition Diagram showing the movement of states (W, D, L) and their probabilities.

## REAL MADRID FC AT HOME

1929/1929	1944/1945
Real Madrid FC <b>0-1</b> FC Barcelona	Real Madrid FC <b>1-0</b> FC Barcelona
1930/1930	1945/1946
Real Madrid FC <b>5-1</b> FC Barcelona	Real Madrid FC <b>3-2</b> FC Barcelona
1931/1931	1946/1947
Real Madrid FC <b>0-0</b> FC Barcelona	Real Madrid FC <b>2-1</b> FC Barcelona
1932/1932	1947/1948
Real Madrid FC <b>2-0</b> FC Barcelona	Real Madrid FC <b>1-1</b> FC Barcelona
1933/1933	1948/1949
Real Madrid FC <b>2-1</b> FC Barcelona	Real Madrid FC <b>1-2</b> FC Barcelona
1933/1934	1944/1944
Real Madrid FC <b>4-0</b> FC Barcelona	Real Madrid FC <b>0-1</b> FC Barcelona
1935/1935	1949/1950
Real Madrid FC <b>8-2</b> FC Barcelona	Real Madrid FC <b>6-1</b> FC Barcelona
1935/1936	1950/1951
Real Madrid FC <b>3-0</b> FC Barcelona	Real Madrid FC <b>4-1</b> FC Barcelona
1940/1940	1951/1952
Real Madrid FC <b>2-1</b> FC Barcelona	Real Madrid FC <b>5-1</b> FC Barcelona
1940/1941	1952/1953
Real Madrid FC <b>1-2</b> FC Barcelona	Real Madrid FC <b>2-1</b> FC Barcelona
1941/1942	1953/1954
Real Madrid FC <b>4-3</b> FC Barcelona	Real Madrid FC <b>5-0</b> FC Barcelona
1942/1943	1954/1955
Real Madrid FC <b>3-0</b> FC Barcelona	Real Madrid FC <b>3-0</b> FC Barcelona
1944/1944	1955/1956
Real Madrid FC <b>0-1</b> FC Barcelona	Real Madrid FC <b>2-1</b> FC Barcelona
	1956/1957

Real Madrid FC **1-0** FC Barcelona

1957/1958

Real Madrid FC **3-0** FC Barcelona

1958/1959

Real Madrid FC **1-0** FC Barcelona

1959/1960

Real Madrid FC **2-0** FC Barcelona

1960/1961

Real Madrid FC **3-2** FC Barcelona

1961/1962

Real Madrid FC **2-0** FC Barcelona

1962/1963

Real Madrid FC **2-0** FC Barcelona

1963/1964

Real Madrid FC **4-0** FC Barcelona

1964/1965

Real Madrid FC **4-1** FC Barcelona

1965/1966

Real Madrid FC **1-3** FC Barcelona

1966/1967

Real Madrid FC **1-0** FC Barcelona

1967/1968

Real Madrid FC **1-1** FC Barcelona

1968/1969

Real Madrid FC **2-1** FC Barcelona

1969/1969

Real Madrid FC **3-3** FC Barcelona

1970/1971

Real Madrid FC **0-1** FC Barcelona

1971/1972

Real Madrid FC **1-1** FC Barcelona

1971/1973

Real Madrid FC **0-0** FC Barcelona

1973/1974

Real Madrid FC **0-5** FC Barcelona

1975/1975

Real Madrid FC **1-0** FC Barcelona

1975/1976

Real Madrid FC **0-2** FC Barcelona

1976/1977

Real Madrid FC **1-1** FC Barcelona

1977/1978

Real Madrid FC **4-0** FC Barcelona

1978/1979

Real Madrid FC **3-1** FC Barcelona

1979/1980

Real Madrid FC **3-2** FC Barcelona

1980/1981

Real Madrid FC **3-0** FC Barcelona

1981/1982

Real Madrid FC **3-1** FC Barcelona

1982/1983

Real Madrid FC **0-2** FC Barcelona

1983/1984

Real Madrid FC **2-1** FC Barcelona

1984/1984

Real Madrid FC **0-3** FC Barcelona

1985/1986  
Real Madrid FC **3-1** FC Barcelona

1986/1987  
Real Madrid FC **1-1** FC Barcelona

1987/1987  
Real Madrid FC **0-0** FC Barcelona

1988/1988  
Real Madrid FC **2-1** FC Barcelona

1988/1989  
Real Madrid FC **3-2** FC Barcelona

1989/1990  
Real Madrid FC **3-2** FC Barcelona

1990/1991  
Real Madrid FC **1-0** FC Barcelona

1991/1992  
Real Madrid FC **1-1** FC Barcelona

1992/1993  
Real Madrid FC **2-1** FC Barcelona

1994/1994  
Real Madrid FC **0-1** FC Barcelona

1995/1995  
Real Madrid FC **5-0** FC Barcelona

1995/1996  
Real Madrid FC **1-1** FC Barcelona

1996/1997  
Real Madrid FC **2-0** FC Barcelona

1997/1998  
Real Madrid FC **2-3** FC Barcelona

1998/1999  
Real Madrid FC **2-2** FC Barcelona

1999/2000  
Real Madrid FC **3-0** FC Barcelona

2000/2001  
Real Madrid FC **2-2** FC Barcelona

2001/2002  
Real Madrid FC **2-0** FC Barcelona

2002/2003  
Real Madrid FC **1-1** FC Barcelona

2003/2004  
Real Madrid FC **1-2** FC Barcelona

2004/2005  
Real Madrid FC **4-2** FC Barcelona

2005/2006  
Real Madrid FC **0-3** FC Barcelona

2006/2007  
Real Madrid FC **2-0** FC Barcelona

2007/2008  
Real Madrid FC **4-1** FC Barcelona

2008/2009  
Real Madrid FC **2-6** FC Barcelona

2009/2010  
Real Madrid FC **0-2** FC Barcelona

2010/2011  
Real Madrid FC **1-1** FC Barcelona

2011/2012  
Real Madrid FC **1-3** FC Barcelona

2012/2013  
Real Madrid FC **2-1** FC Barcelona



2013/2014  
Real Madrid FC **3-4** FC Barcelona

2014/2015  
Real Madrid FC **3-1** FC Barcelona

2015/2016  
Real Madrid FC **0-4** FC Barcelona

2016/2017  
Real Madrid FC **2-3** FC Barcelona

2017/2018  
Real Madrid FC **0-3** FC Barcelona

2018/2019  
Real Madrid FC **0-1** FC Barcelona

2019/2020  
Real Madrid FC **2-0** FC Barcelona

2020/2021  
Real Madrid FC **2-0** FC Barcelona

## THE TRANSITION MATRIX FOR REAL MADRID FC AT HOME WITH BARCELONA FC

### DATA

L W D W W W W W W L L W W W D L W W W W W W W W W W  
W W W W L W D W D L D D L W L D W W W W W L W L W D D W W W  
W D W L W D W L D W D W D L W L W W L L D L W L W L L L L W W

Number of Wins = 54  
Number of Draws = 15  
Number of Loses = 22  
Total number of matches played = 91

### Matrix

$$p = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} WW & WD & WL \\ DW & DD & DL \\ LW & LD & LL \end{pmatrix} \end{matrix}$$

Where

W denotes Win  
D denotes Draw  
L denotes Loss

$$p = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 33 & 9 & 11 \\ 8 & 2 & 5 \\ 13 & 4 & 5 \end{pmatrix} \end{matrix}$$

$$p_{ij} = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} \cancel{33}/\cancel{53} & \cancel{9}/\cancel{53} & \cancel{11}/\cancel{53} \\ \cancel{8}/\cancel{15} & \cancel{2}/\cancel{15} & \cancel{5}/\cancel{15} \\ \cancel{13}/\cancel{22} & \cancel{4}/\cancel{22} & \cancel{5}/\cancel{22} \end{pmatrix} \end{matrix}$$

## PROBABILITY TRANSITIONAL MATRIX

```
MH <- matrix(c(0.62, 0.17, 0.21, 0.53, 0.13, 0.34, 0.59, 0.18, 0.23),
             nrow = 3, byrow = T, dimnames = list(states, states))
MH
```

$$p_{ij} = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 0.62 & 0.17 & 0.21 \\ 0.53 & 0.13 & 0.34 \\ 0.59 & 0.18 & 0.23 \end{pmatrix} \end{matrix}$$

```
Mh.laliga<- new("markovchain", states = states, byrow = T, transitionMatrix =
MH, name = "Real Madrid FC At Home La Liga")
Mh.laliga
```

Real Madrid FC At Home La Liga

A 3 - dimensional discrete Markov Chain defined by the following states:

W, D, L

The transition matrix (by rows) is defined as follows:

$$p_{ij} = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 0.62 & 0.17 & 0.21 \\ 0.53 & 0.13 & 0.34 \\ 0.59 & 0.18 & 0.23 \end{pmatrix} \end{matrix}$$

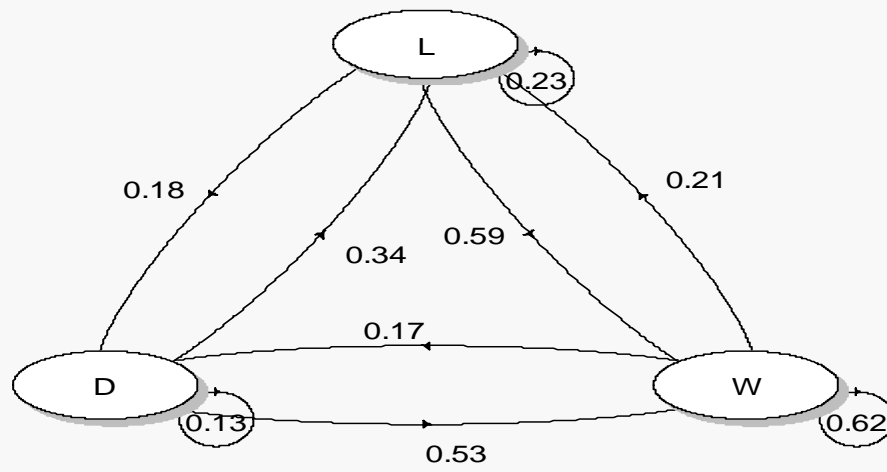
## PROBABILITY OF PLAYING TWO CONSECUTIVE MATCHES

```
transitionProbability(Mh.laliga,"W","W")
[1] 0.62
transitionProbability(Mh.laliga,"W","D")
[1] 0.17
transitionProbability(Mh.laliga,"W","L")
[1] 0.21
transitionProbability(Mh.laliga,"D","W")
[1] 0.53
transitionProbability(Mh.laliga,"D","D")
[1] 0.13
transitionProbability(Mh.laliga,"D","L")
[1] 0.34
transitionProbability(Mh.laliga,"L","W")
[1] 0.59
transitionProbability(Mh.laliga,"L","D")
[1] 0.18
transitionProbability(Mh.laliga,"L","L")
[1] 0.23
```

## THE FOR STEADY STATE/LONG RUN PROBABILITY

```
steadyStates(Mh.laliga)
      W      D      L
[1,] 0.5979959 0.1657334 0.2362708
round(steadyStates(Mh.laliga),2)
      W      D      L
[1,] 0.6 0.17 0.24
```

**Transition Diagram Of Real Madrid FC At Home**



### INTERPRETATION

Our research shows that Real Madrid FC has a 62% chance of winning, 17% of drawing and 24% of losing when playing at home to FC Barcelona in the Primera Division (La Liga) games. Also, Real Madrid FC has 62% chances of winning two consecutive matches, 13% chances of drawing two consecutive matches, 23% chances of losing two consecutive matches, 17% chances of winning-drawing two straight matches, 21% chances of winning-losing two straight matches, 53% chances of drawing-winning two straight matches, 34% chances of drawing-losing two straight matches, 59% chances of losing-winning two straight matches, and 18% chances of losing-drawing two straight matches when playing at home to FC Barcelona in the Primera Division (La Liga) games. Above is the Transition Diagram showing the movement of states (W, D, L) and their probabilities.

## FC BARCELONA AT AWAY

1929/1929	1944/1945
Real Madrid FC <b>0-1</b> FC Barcelona	Real Madrid FC <b>1-0</b> FC Barcelona
1930/1930	1945/1946
Real Madrid FC <b>5-1</b> FC Barcelona	Real Madrid FC <b>3-2</b> FC Barcelona
1931/1931	1946/1947
Real Madrid FC <b>0-0</b> FC Barcelona	Real Madrid FC <b>2-1</b> FC Barcelona
1932/1932	1947/1948
Real Madrid FC <b>2-0</b> FC Barcelona	Real Madrid FC <b>1-1</b> FC Barcelona
1933/1933	1948/1949
Real Madrid FC <b>2-1</b> FC Barcelona	Real Madrid FC <b>1-2</b> FC Barcelona
1933/1934	1944/1944
Real Madrid FC <b>4-0</b> FC Barcelona	Real Madrid FC <b>0-1</b> FC Barcelona
1935/1935	1949/1950
Real Madrid FC <b>8-2</b> FC Barcelona	Real Madrid FC <b>6-1</b> FC Barcelona
1935/1936	1950/1951
Real Madrid FC <b>3-0</b> FC Barcelona	Real Madrid FC <b>4-1</b> FC Barcelona
1940/1940	1951/1952
Real Madrid FC <b>2-1</b> FC Barcelona	Real Madrid FC <b>5-1</b> FC Barcelona
1940/1941	1952/1953
Real Madrid FC <b>1-2</b> FC Barcelona	Real Madrid FC <b>2-1</b> FC Barcelona
1941/1942	1953/1954
Real Madrid FC <b>4-3</b> FC Barcelona	Real Madrid FC <b>5-0</b> FC Barcelona
1942/1943	1954/1955
Real Madrid FC <b>3-0</b> FC Barcelona	Real Madrid FC <b>3-0</b> FC Barcelona
1944/1944	1955/1956
Real Madrid FC <b>0-1</b> FC Barcelona	Real Madrid FC <b>2-1</b> FC Barcelona
	1956/1957

Real Madrid FC **1-0** FC Barcelona

1957/1958

Real Madrid FC **3-0** FC Barcelona

1958/1959

Real Madrid FC **1-0** FC Barcelona

1959/1960

Real Madrid FC **2-0** FC Barcelona

1960/1961

Real Madrid FC **3-2** FC Barcelona

1961/1962

Real Madrid FC **2-0** FC Barcelona

1962/1963

Real Madrid FC **2-0** FC Barcelona

1963/1964

Real Madrid FC **4-0** FC Barcelona

1964/1965

Real Madrid FC **4-1** FC Barcelona

1965/1966

Real Madrid FC **1-3** FC Barcelona

1966/1967

Real Madrid FC **1-0** FC Barcelona

1967/1968

Real Madrid FC **1-1** FC Barcelona

1968/1969

Real Madrid FC **2-1** FC Barcelona

1969/1969

Real Madrid FC **3-3** FC Barcelona

1970/1971

Real Madrid FC **0-1** FC Barcelona

1971/1972

Real Madrid FC **1-1** FC Barcelona

1971/1973

Real Madrid FC **0-0** FC Barcelona

1973/1974

Real Madrid FC **0-5** FC Barcelona

1975/1975

Real Madrid FC **1-0** FC Barcelona

1975/1976

Real Madrid FC **0-2** FC Barcelona

1976/1977

Real Madrid FC **1-1** FC Barcelona

1977/1978

Real Madrid FC **4-0** FC Barcelona

1978/1979

Real Madrid FC **3-1** FC Barcelona

1979/1980

Real Madrid FC **3-2** FC Barcelona

1980/1981

Real Madrid FC **3-0** FC Barcelona

1981/1982

Real Madrid FC **3-1** FC Barcelona

1982/1983

Real Madrid FC **0-2** FC Barcelona

1983/1984

Real Madrid FC **2-1** FC Barcelona

1984/1984

Real Madrid FC **0-3** FC Barcelona

1985/1986  
Real Madrid FC **3-1** FC Barcelona

1986/1987  
Real Madrid FC **1-1** FC Barcelona

1987/1987  
Real Madrid FC **0-0** FC Barcelona

1988/1988  
Real Madrid FC **2-1** FC Barcelona

1988/1989  
Real Madrid FC **3-2** FC Barcelona

1989/1990  
Real Madrid FC **3-2** FC Barcelona

1990/1991  
Real Madrid FC **1-0** FC Barcelona

1991/1992  
Real Madrid FC **1-1** FC Barcelona

1992/1993  
Real Madrid FC **2-1** FC Barcelona

1994/1994  
Real Madrid FC **0-1** FC Barcelona

1995/1995  
Real Madrid FC **5-0** FC Barcelona

1995/1996  
Real Madrid FC **1-1** FC Barcelona

1996/1997  
Real Madrid FC **2-0** FC Barcelona

1997/1998  
Real Madrid FC **2-3** FC Barcelona

1998/1999  
Real Madrid FC **2-2** FC Barcelona

1999/2000  
Real Madrid FC **3-0** FC Barcelona

2000/2001  
Real Madrid FC **2-2** FC Barcelona

2001/2002  
Real Madrid FC **2-0** FC Barcelona

2002/2003  
Real Madrid FC **1-1** FC Barcelona

2003/2004  
Real Madrid FC **1-2** FC Barcelona

2004/2005  
Real Madrid FC **4-2** FC Barcelona

2005/2006  
Real Madrid FC **0-3** FC Barcelona

2006/2007  
Real Madrid FC **2-0** FC Barcelona

2007/2008  
Real Madrid FC **4-1** FC Barcelona

2008/2009  
Real Madrid FC **2-6** FC Barcelona

2009/2010  
Real Madrid FC **0-2** FC Barcelona

2010/2011  
Real Madrid FC **1-1** FC Barcelona

2011/2012  
Real Madrid FC **1-3** FC Barcelona

2012/2013  
Real Madrid FC **2-1** FC Barcelona

2013/2014  
Real Madrid FC **3-4** FC Barcelona

2014/2015  
Real Madrid FC **3-1** FC Barcelona

2015/2016  
Real Madrid FC **0-4** FC Barcelona

2016/2017  
Real Madrid FC **2-3** FC Barcelona

2017/2018  
Real Madrid FC **0-3** FC Barcelona

2018/2019  
Real Madrid FC **0-1** FC Barcelona

2019/2020  
Real Madrid FC **2-0** FC Barcelona

2020/2021  
Real Madrid FC **2-0** FC Barcelona

## THE TRANSITION MATRIX FOR BARCELONA FC AT AWAY WITH REAL MADRID FC

### DATA

W L D L L L L L L W L L W L L L D W L L L L L L L L L L  
L L L L W L D L D W D D W L W D L L L L W L W L D D L L L  
L D L W L D L W D L D L D W L W L L W W D W L W L W W L L

Number of Wins = 22  
Number of Draws = 15  
Number of Loses = 54  
Total number of matches played = 91

### Matrix

$$p = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} WW & WD & WL \\ DW & DD & DL \\ LW & LD & LL \end{pmatrix} \end{matrix}$$

Where

W denotes Win  
D denotes Draw  
L denotes Loss



$$p = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 4 & 4 & 14 \\ 5 & 2 & 8 \\ 12 & 9 & 32 \end{pmatrix} \end{matrix}$$

$$p_{ij} = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} \frac{4}{22} & \frac{4}{22} & \frac{14}{22} \\ \frac{5}{15} & \frac{2}{15} & \frac{8}{15} \\ \frac{12}{53} & \frac{9}{53} & \frac{32}{53} \end{pmatrix} \end{matrix}$$

## PROBABILITY TRANSITIONAL MATRIX

```
BA <- matrix(c(0.18, 0.18, 0.64, 0.34, 0.13, 0.53, 0.23, 0.17, 0.60),
             nrow = 3, byrow = T, dimnames = list(states, states))
```

BA

$$p_{ij} = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 0.18 & 0.18 & 0.64 \\ 0.34 & 0.13 & 0.53 \\ 0.23 & 0.17 & 0.60 \end{pmatrix} \end{matrix}$$

```
Ba.laliga<- new("markovchain", states = states, byrow = T, transitionMatrix =
BA, name = "FC Barcelona At Away La Liga")
```

Ba.laliga

FC Barcelona At Away La Liga

A 3 - dimensional discrete Markov Chain defined by the following states:

W, D, L

The transition matrix (by rows) is defined as follows:

$$p_{ij} = \begin{matrix} & \begin{matrix} W & D & L \end{matrix} \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 0.18 & 0.18 & 0.64 \\ 0.34 & 0.13 & 0.53 \\ 0.23 & 0.17 & 0.60 \end{pmatrix} \end{matrix}$$

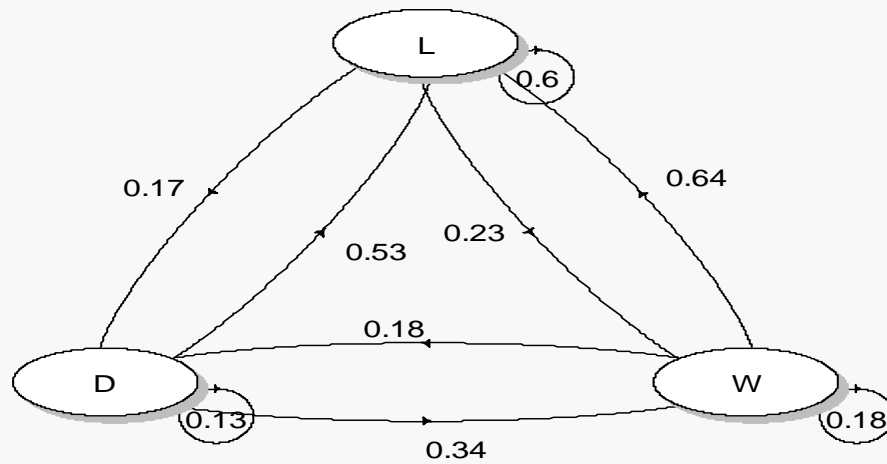
## PROBABILITY OF PLAYING TWO CONSECUTIVE MATCHES

```
transitionProbability(Ba.laliga,"W","W")
[1] 0.18
transitionProbability(Ba.laliga,"W","D")
[1] 0.18
transitionProbability(Ba.laliga,"W","L")
[1] 0.64
transitionProbability(Ba.laliga,"D","W")
[1] 0.34
transitionProbability(Ba.laliga,"D","D")
[1] 0.13
transitionProbability(Ba.laliga,"D","L")
[1] 0.53
transitionProbability(Ba.laliga,"L","W")
[1] 0.23
transitionProbability(Ba.laliga,"L","D")
[1] 0.17
transitionProbability(Ba.laliga,"L","L")
[1] 0.6
```

## THE FOR STEADY STATE/LONG RUN PROBABILITY

```
steadyStates(Ba.laliga)
      W      D      L
[1,] 0.2364103 0.1657347 0.597855
round(steadyStates(Ba.laliga),2)
      W      D      L
[1,] 0.24 0.16 0.6
```

**Transition Diagram Of Barcelona FC At Away**



### INTERPRETATION

Our research shows that FC Barcelona has a 24% chance of winning, 16% of drawing and 60% of losing when playing away to Real Madrid FC in the Primera Division (La Liga) games. Also, FC Barcelona has 18% chances of winning two consecutive matches, 13% chances of drawing two consecutive matches, 60% chances of losing two consecutive matches, 18% chances of winning-drawing two straight matches, 64% chances of winning-losing two straight matches, 34% chances of drawing-winning two straight matches, 53% chances of drawing-losing two straight matches, 23% chances of losing-winning two straight matches, and 17% chances of losing-drawing two straight matches when playing at away to Real Madrid FC in the Primera Division (La Liga) games. Above is the Transition Diagram showing the movement of states (W, D, L) and their probabilities.

## REAL MADRID FC AT AWAY

1929/1929	1945/1946
FC Barcelona <b>1-2</b> Real Madrid FC	FC Barcelona <b>1-0</b> Real Madrid FC
1930/1930	1946/1947
FC Barcelona <b>1-4</b> Real Madrid FC	FC Barcelona <b>3-2</b> Real Madrid FC
1931/1931	1947/1948
FC Barcelona <b>3-1</b> Real Madrid FC	FC Barcelona <b>4-2</b> Real Madrid FC
1932/1932	1948/1949
FC Barcelona <b>2-2</b> Real Madrid FC	FC Barcelona <b>3-1</b> Real Madrid FC
1933/1933	1944/1944
FC Barcelona <b>1-1</b> Real Madrid FC	FC Barcelona <b>1-2</b> Real Madrid FC
1933/1934	1949/1950
FC Barcelona <b>1-2</b> Real Madrid FC	FC Barcelona <b>2-3</b> Real Madrid FC
1935/1935	1950/1951
FC Barcelona <b>5-0</b> Real Madrid FC	FC Barcelona <b>7-2</b> Real Madrid FC
1935/1936	1951/1952
FC Barcelona <b>3-0</b> Real Madrid FC	FC Barcelona <b>4-2</b> Real Madrid FC
1940/1940	1952/1953
FC Barcelona <b>0-0</b> Real Madrid FC	FC Barcelona <b>1-0</b> Real Madrid FC
1940/1941	1953/1954
FC Barcelona <b>3-0</b> Real Madrid FC	FC Barcelona <b>5-1</b> Real Madrid FC
1941/1942	1954/1955
FC Barcelona <b>0-2</b> Real Madrid FC	FC Barcelona <b>2-2</b> Real Madrid FC
1942/1943	1955/1956
FC Barcelona <b>5-5</b> Real Madrid FC	FC Barcelona <b>2-0</b> Real Madrid FC
1944/1944	1956/1957
FC Barcelona <b>1-2</b> Real Madrid FC	FC Barcelona <b>1-0</b> Real Madrid FC
1944/1945	1957/1958
FC Barcelona <b>5-0</b> Real Madrid FC	

FC Barcelona **0-2** Real Madrid FC  
1958/1959

FC Barcelona **4-0** Real Madrid FC  
1959/1960

FC Barcelona **3-1** Real Madrid FC  
1960/1961

FC Barcelona **3-5** Real Madrid FC  
1961/1962

FC Barcelona **3-1** Real Madrid FC  
1962/1963

FC Barcelona **1-5** Real Madrid FC  
1963/1964

FC Barcelona **1-2** Real Madrid FC  
1964/1965

FC Barcelona **1-2** Real Madrid FC  
1965/1966

FC Barcelona **2-1** Real Madrid FC  
1966/1967

FC Barcelona **2-1** Real Madrid FC  
1967/1968

FC Barcelona **1-1** Real Madrid FC  
1968/1969

FC Barcelona **1-1** Real Madrid FC  
1969/1969

FC Barcelona **1-0** Real Madrid FC  
1970/1971

FC Barcelona **0-1** Real Madrid FC  
1971/1972

FC Barcelona **1-0** Real Madrid FC  
1971/1973

FC Barcelona **1-0** Real Madrid FC  
1973/1974

FC Barcelona **0-0** Real Madrid FC  
Real Madrid FC **0-5** FC Barcelona  
1975/1975

Real Madrid FC **1-0** FC Barcelona  
FC Barcelona **0-0** Real Madrid FC  
1975/1976

FC Barcelona **2-1** Real Madrid FC  
1976/1977

FC Barcelona **3-1** Real Madrid FC  
1977/1978

FC Barcelona **2-3** Real Madrid FC  
1978/1979

FC Barcelona **2-0** Real Madrid FC  
1979/1980

FC Barcelona **0-2** Real Madrid FC  
1980/1981

FC Barcelona **2-1** Real Madrid FC  
1981/1982

FC Barcelona **3-1** Real Madrid FC  
1982/1983

FC Barcelona **2-1** Real Madrid FC  
1983/1984

FC Barcelona **1-2** Real Madrid FC  
1984/1984

FC Barcelona **3-2** Real Madrid FC  
1985/1986

FC Barcelona **2-0** Real Madrid FC  
1986/1987

FC Barcelona **3-2** Real Madrid FC  
1987/1987

FC Barcelona **2-1** Real Madrid FC  
1988/1988

FC Barcelona **2-0** Real Madrid FC  
1988/1989

FC Barcelona **0-0** Real Madrid FC  
1989/1990

FC Barcelona **3-1** Real Madrid FC  
1990/1991

FC Barcelona **2-1** Real Madrid FC  
1991/1992

FC Barcelona **1-1** Real Madrid FC  
1992/1993

FC Barcelona **2-1** Real Madrid FC  
1994/1994

FC Barcelona **5-0** Real Madrid FC  
1995/1995

FC Barcelona **1-0** Real Madrid FC  
1995/1996

FC Barcelona **3-0** Real Madrid FC  
1996/199

FC Barcelona **1-0** Real Madrid FC  
1997/1998

FC Barcelona **3-0** Real Madrid FC  
1998/1999

FC Barcelona **3-0** Real Madrid FC  
1999/2000

FC Barcelona **2-2** Real Madrid FC  
2000/2001

FC Barcelona **2-0** Real Madrid FC  
2001/2002

FC Barcelona **1-1** Real Madrid FC  
2002/2003

FC Barcelona **0-0** Real Madrid FC  
2003/2004

FC Barcelona **1-2** Real Madrid FC  
2004/2005

FC Barcelona **3-0** Real Madrid FC  
2005/2006

FC Barcelona **1-1** Real Madrid FC  
2006/2007

FC Barcelona **3-3** Real Madrid FC  
2007/2008

FC Barcelona **0-1** Real Madrid FC  
2008/2009

FC Barcelona **2-0** Real Madrid FC  
2009/2010

FC Barcelona **1-0** Real Madrid FC  
2010/2011

FC Barcelona **5-0** Real Madrid FC  
2011/2012

FC Barcelona **1-2** Real Madrid FC  
2012/2013

FC Barcelona **2-2** Real Madrid FC  
2013/2014

FC Barcelona **2-1** Real Madrid FC  
2014/2015

FC Barcelona **2-1** Real Madrid FC  
2015/2016

FC Barcelona 1-2 Real Madrid FC  
2016/2017

FC Barcelona 1-1 Real Madrid FC  
2017/2018

FC Barcelona 2-2 Real Madrid FC  
2018/2019

FC Barcelona 5-1 Real Madrid FC  
2019/2020

FC Barcelona 0-0 Real Madrid FC  
2020/2021

FC Barcelona 1-3 Real Madrid FC

## THE TRANSITION MATRIX FOR REAL MADRID FC AT AWAY WITH BARCELONA FC

### DATA

W W L D D W L W D L W D W L L L L L W L L L L D L L W L L W  
L W W W L L D D L W L L D D L L W L W L L L W L L L L L D L  
L D L L L L L L L D L D D W L D D W L L L W D L L W D D L D W

Number of Wins = 21

Number of Draws = 20

Number of Loses = 50

Total number of matches played = 91

### Matrix

$$p = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} WW & WD & WL \\ DW & DD & DL \\ LW & LD & LL \end{pmatrix} \end{matrix}$$

Where

W denotes Win

D denotes Draw

L denotes Loss

$$p = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 3 & 4 & 13 \\ 5 & 6 & 9 \\ 12 & 10 & 28 \end{pmatrix} \end{matrix}$$

$$p_{ij} = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 3/20 & 4/20 & 13/20 \\ 5/20 & 6/20 & 9/20 \\ 12/50 & 10/50 & 28/50 \end{pmatrix} \end{matrix}$$

## PROBABILITY TRANSITIONAL MATRIX

```
MA <- matrix(c(0.15, 0.20, 0.65, 0.25, 0.30, 0.45, 0.24, 0.20, 0.56),
             nrow = 3, byrow = T, dimnames = list(states, states))
MA
```

$$p_{ij} = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 0.15 & 0.20 & 0.65 \\ 0.25 & 0.30 & 0.45 \\ 0.24 & 0.20 & 0.56 \end{pmatrix} \end{matrix}$$

```
Ma.laliga<- new("markovchain", states = states, byrow = T, transitionMatrix =
MA, name = "Real Madrid FC At Away La Liga")
Ma.laliga
```

Real Madrid FC At Away La Liga

A 3 - dimensional discrete Markov Chain defined by the following states:

W, D, L

The transition matrix (by rows) is defined as follows:

$$p_{ij} = \begin{matrix} & W & D & L \\ \begin{matrix} W \\ D \\ L \end{matrix} & \begin{pmatrix} 0.15 & 0.20 & 0.65 \\ 0.25 & 0.30 & 0.45 \\ 0.24 & 0.20 & 0.56 \end{pmatrix} \end{matrix}$$

## PROBABILITY OF PLAYING TWO CONSECUTIVE MATCHES

```
transitionProbability(Ma.laliga,"W","W")
```

```
[1] 0.15
```



```

transitionProbability(Ma.laliga,"W","D")
[1] 0.2
transitionProbability(Ma.laliga,"W","L")
[1] 0.65
transitionProbability(Ma.laliga,"D","W")
[1] 0.25
transitionProbability(Ma.laliga,"D","D")
[1] 0.3
transitionProbability(Ma.laliga,"D","L")
[1] 0.45
transitionProbability(Ma.laliga,"L","W")
[1] 0.24
transitionProbability(Ma.laliga,"L","D")
[1] 0.2
transitionProbability(Ma.laliga,"L","L")
[1] 0.56

```

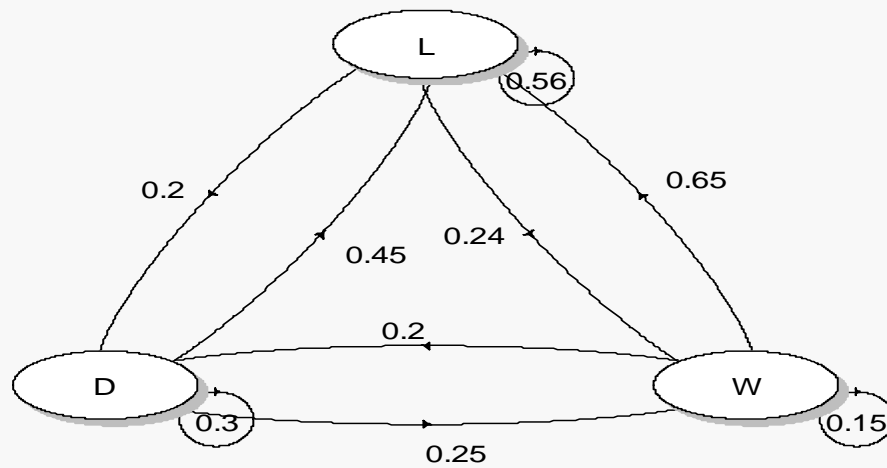
#### THE FOR STEADY STATE/LONG RUN PROBABILITY

```

steadyStates(Ma.laliga)
      W      D      L
[1,] 0.2222222 0.2222222 0.5555556
round(steadyStates(Ma.laliga),2)
      W      D      L
[1,] 0.22 0.22 0.56

```

**Transition Diagram Of Real Madrid FC At Away**



## INTERPRETATION

Our research shows that Real Madrid FC has a 22% chance of winning, 22% of drawing and 56% of losing when playing away to FC Barcelona in the Primera Division (La Liga) games. Also, Real Madrid FC has 15% chances of winning two consecutive matches, 30% chances of drawing two consecutive matches, 56% chances of losing two consecutive matches, 20% chances of winning-drawing two straight matches, 65% chances of winning-losing two straight matches, 25% chances of drawing-winning two straight matches, 45% chances of drawing-losing two straight matches, 24% chances of losing-winning two straight matches, and 20% chances of losing-drawing two straight matches when playing at away to FC Barcelona in the Primera Division (La Liga) games. Above is the Transition Diagram showing the movement of states (W, D, L) and their probabilities.

## THE TRANSITION MATRIX FOR OVER/UNDER 1.5 GOALS BETWEEN REAL MADRID FC AND BARCELONA FC FOR BOTH HOME AND AWAY.

### DATA

```

O U O O U O O O O O O O O O O O O U O O O O O O U O U O O U
O O O O O O O O O O O O O O O U O O O O O O U U O O O U O O O O
O O O O O O O O O O O U O O O O O O U U U O U U U U O U U O O
O O O O O O O O O O O O O O O O O O O O O O U O O O O U O O
O U O O O O O U O U O O O U O O O O O O O O O O U O O O O O
O O O O U O O O U O O O O O O O O O O O O O O O O O O U U O O O

```

Number of Overs = 151

Number of Unders = 31

Total number of matches played = 182

Where

O denote Over

U denote Under

### Matrix

$$P = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} OO & OU \\ UO & UU \end{pmatrix} \end{matrix}$$

$$P = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} 127 & 23 \\ 23 & 8 \end{pmatrix} \end{matrix}$$

$$P_{ij} = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} 127/150 & 23/150 \\ 23/31 & 8/31 \end{pmatrix} \end{matrix}$$

### STATES

```
states <- c("O", "U")
```

## PROBABILITY TRANSITIONAL MATRIX

```
OV1.5 <- matrix(c(0.85, 0.15, 0.74, 0.26),  
               nrow = 2, byrow = T, dimnames = list(states, states))
```

OV1.5

$$P_{ij} = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} 0.85 & 0.15 \\ 0.74 & 0.26 \end{pmatrix} \end{matrix}$$

```
Ov1.5 <- new("markovchain", states = states, byrow = T, transitionMatrix = OV  
1.5, name = "Over/Under 1.5")
```

Ov1.5

Over/Under 1.5

A 2 - dimensional discrete Markov Chain defined by the following states:

O, U

The transition matrix (by rows) is defined as follows:

$$P_{ij} = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} 0.85 & 0.15 \\ 0.74 & 0.26 \end{pmatrix} \end{matrix}$$

## PROBABILITY OF PLAYING TWO CONSECUTIVE MATCHES

```
transitionProbability(Ov1.5,"O","O")
```

```
## [1] 0.85
```

```
transitionProbability(Ov1.5,"O","U")
```

```
## [1] 0.15
```

```
transitionProbability(Ov1.5,"U","O")
```

```
## [1] 0.74
```

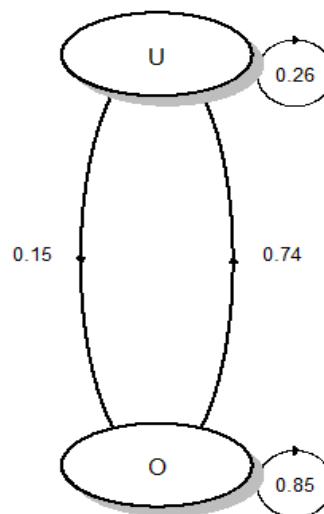
```
transitionProbability(Ov1.5,"U","U")
```

```
## [1] 0.26
```

## THE FOR STEADY STATE/LONG RUN PROBABILITY

```
steadyStates(0v1.5)
      O      U
[1,] 0.8314607 0.1685393
round(steadyStates(0v1.5),2)
      O      U
[1,] 0.83 0.17
```

**Transitional Diagram Of Over/Under 1.5 Goals**



## INTERPRETATION

Our research shows that FC Barcelona vs Real Madrid FC has an 83% chance of playing over 1.5 goals and a 17% chance of playing under 1.5 goals when playing in the Primera Division (La Liga) games. Also, FC Barcelona vs Real Madrid FC has 85% chances of playing over 1.5 goals in two consecutive matches, 26% chances of playing under 1.5 goals in two consecutive matches, 15% chances of playing over-under 1.5 goals in two straight matches, and 74% chances of playing under-over 1.5 goals in two straight matches when playing in the Primera Division (La Liga) games. Above is the Transition Diagram showing movement of states (O, U) and their probabilities.

## THE TRANSITION MATRIX FOR OVER/UNDER 2.5 GOALS BETWEEN REAL MADRID FC AND BARCELONA FC FOR BOTH HOME AND AWAY.

### DATA

```

O U O O U O U O U O O O O O O O O U O O O U O O U O U O O U O O U O O
O O O O O O O O U O O O O O O U U U O U O U U O O O U O U O O O O O O O
U O U U O U O U U U U U U U U O U U O U O U O O O U O U O O O O O U O O
O O O U O U O U O O U O U O O O U U U O O O U O U U O U U O O O O O O O
U O U U U U O O O O O U U O U O U O U U O U O O O O O O O O O O O U O O
O O U U U U O

```

Number of Overs = 114

Number of Unders = 68

Total number of matches played = 182

Where

O denote Over

U denote Under

### Matrix

$$P = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} OO & OU \\ UO & UU \end{pmatrix} \end{matrix}$$

$$P = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} 69 & 44 \\ 44 & 24 \end{pmatrix} \end{matrix}$$

$$P_{ij} = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} 69/114 & 44/114 \\ 44/68 & 24/24 \end{pmatrix} \end{matrix}$$

### PROBABILITY TRANSITIONAL MATRIX

```

OV2.5 <- matrix(c(0.61, 0.39, 0.65, 0.35),
                nrow = 2, byrow = T, dimnames = list(states, states))

```

OV2.5

$$P_{ij} = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} 0.61 & 0.39 \\ 0.65 & 0.35 \end{pmatrix} \end{matrix}$$

```
Ov2.5 <- new("markovchain", states = states, byrow = T, transitionMatrix = Ov2.5, name = "Over/Under 2.5")
```

```
Ov2.5
```

```
Over/Under 2.5
```

```
A 2 - dimensional discrete Markov Chain defined by the following states:
```

```
0, U
```

```
The transition matrix (by rows) is defined as follows:
```

$$P_{ij} = \begin{matrix} & \begin{matrix} O & U \end{matrix} \\ \begin{matrix} O \\ U \end{matrix} & \begin{pmatrix} 0.61 & 0.39 \\ 0.65 & 0.35 \end{pmatrix} \end{matrix}$$

### PROBABILITY OF PLAYING TWO CONSECUTIVE MATCHES

```
transitionProbability(Ov2.5,"0","0")
```

```
[1] 0.61
```

```
transitionProbability(Ov2.5,"0","U")
```

```
[1] 0.39
```

```
transitionProbability(Ov2.5,"U","0")
```

```
[1] 0.65
```

```
transitionProbability(Ov2.5,"U","U")
```

```
[1] 0.35
```

### THE FOR STEADY STATE/LONG RUN PROBABILITY

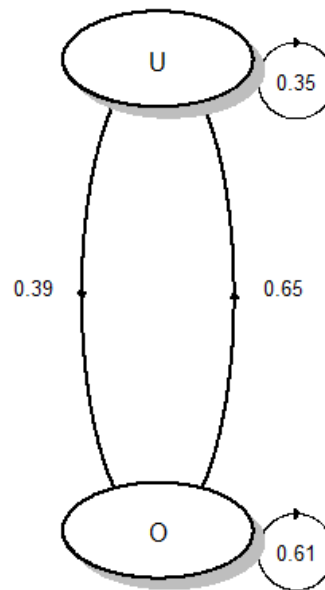
```
steadyStates(Ov2.5)
```

```
      0      U  
[1,] 0.625 0.375
```

```
round(steadyStates(Ov2.5),2)
```

```
      0      U  
[1,] 0.63 0.37
```

**Transitional Diagram Of Over/Under 2.5 Goals**



### INTERPRETATION

Our research shows that FC Barcelona vs Real Madrid FC has a 63% chance of playing over 2.5 goals and a 37% chance of playing under 2.5 goals when playing in the Primera Division (La Liga) games. Also, FC Barcelona vs Real Madrid FC has 61% chances of playing over 2.5 goals in two consecutive matches, 35% chances of playing under 2.5 goals in two consecutive matches, 39% chances of playing over-under 2.5 goals in two straight matches, and 65% chances of playing under-over 2.5 goals in two straight matches when playing in the Primera Division (La Liga) games. Above is the Transition Diagram showing the movement of states (O, U) and their probabilities.