

Ejercicio

Uriel Paluch

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```
DerivadaPorDefinicion <- function(x, fx){
  fprima <- rep(NA, times = length(x))

  #Se asume que todos los valores estan separados por un h constante
  h <- x[2] - x[1]

  #Diferencia progresiva
  for (i in 1:(length(x)-1)){
    fprima[i] <- (fx[i+1] - fx[i]) / h
  }

  #Diferencia regresiva
  for (i in (length(x):2)) {
    fprimaReg <- (fx[i-1] - fx[i]) / (-h)

    if (!is.na(fprima[i])){
      if(fprimaReg != fprima[i]){
        aux <- fprima[i]
        fprima[i] <- glue::glue(aux, " (P)",
                                " o ",
                                fprimaReg, " (R)" )
      }
    } else{
      fprima[i] <- fprimaReg
    }
  }

  resultado <- data.frame(x, fx, fprima)

  return(resultado)
}

SplineNatural <- function(x, y){
  #browser()
  n <- length(x)

  # Paso 1
  h <- rep(NA, times = (n-1))
  for (i in 1:(n-1)) {
    h[i] <- x[i+1] - x[i]
  }; rm(i)
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# Paso 2
alfa <- rep(NA, times = (n-2))
for (i in 2:(n-1)) {
  alfa[i] <- (3/h[i]) * (y[i+1] - y[i]) - (3/h[i-1]) * (y[i] - y[i-1])
}

# Paso 3
mu <- rep(NA, times = n)
zeta <- rep(NA, times = n)
l <- rep(NA, times = n)

mu[1] <- 0
zeta[1] <- 0
l[1] <- 1

# Paso 4
for (i in 2:(n-1)) {
  l[i] <- 2 * (x[i+1] - x[i-1]) - h[i-1] * mu[i-1]
  mu[i] <- h[i]/l[i]
  zeta[i] <- (alfa[i] - h[i-1] * zeta[i-1])/l[i]
}

# Paso 5
l[n] <- 1
zeta[n] <- 0
c <- rep(NA, times = n)
c[n] <- 0

# Paso 6
b <- rep(NA, times = (n-1))
d <- rep(NA, times = (n-1))
for (j in (n-1):1) {
  c[j] <- zeta[j] - mu[j] * c[j+1]
  b[j] <- (y[j+1] - y[j]) / h[j] - h[j] * (c[j+1] + 2 * c[j])/3
  d[j] <- (c[j+1] - c[j]) / (3*h[j])
}

# Paso 7
resultados <- matrix(rep(NA, 4*(n-1)), nrow = (n-1), ncol = 4, byrow = F)
for (k in 1:(n-1)) {
  resultados[k, 1] <- y[k]
  resultados[k, 2] <- b[k]
  resultados[k, 3] <- c[k]
  resultados[k, 4] <- d[k]
}

print(resultados)

#Construyo el polinomio
polinomios <- rep(NA, times = nrow(resultados))
for (i in 1:nrow(resultados)) {
  polinomios[i] <- glue::glue(resultados[i,1])
}

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    for(j in 2:ncol(resultados)){
      polinomios[i] <- polinomios[i] + glue::glue(" + ", resultados[i,j], " * (x - ", x[i], ")^", (j-1))
    }
  }

  return(polinomios)
}

SplineCondicionado <- function(x, y, fpo, fpn){
  #browser()
  n <- length(x)

  # Paso 1
  h <- rep(NA, times = (n-1))
  for (i in 1:(n-1)) {
    h[i] <- x[i+1] - x[i]
  }; rm(i)

  # Paso 2
  alfa <- rep(NA, times = n)
  alfa[1] <- 3 * (y[2] - y[1])/h[1] - 3 * fpo
  alfa[n] <- 3 * fpn - 3 * (y[n] - y[n-1]) / h[n-1]

  # Paso 3
  for (i in 2:(n-1)) {
    alfa[i] <- (3/h[i]) * (y[i+1] - y[i]) - (3/h[i-1]) * (y[i] - y[i-1])
  }; rm(i)

  # Paso 4
  mu <- rep(NA, times = n)
  zeta <- rep(NA, times = n)
  l <- rep(NA, times = n)

  l[1] <- 2 * h[1]
  mu[1] <- 0.5
  zeta[1] <- alfa[1]/l[1]

  # Paso 5
  for (i in 2:(n-1)) {
    l[i] <- 2 * (x[i+1] - x[i-1]) - h[i-1] * mu[i-1]
    mu[i] <- h[i]/l[i]
    zeta[i] <- (alfa[i] - h[i-1] * zeta[i-1])/l[i]
  }

  # Paso 6
  l[n] <- h[n-1] * (2 - mu[n-1])
  zeta[n] <- (alfa[n] - h[n-1] * zeta[n-1]) / l[n]
  c <- rep(NA, times = n)
  c[n] <- zeta[n]

  # Paso 7
  b <- rep(NA, times = (n-1))

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d <- rep(NA, times = (n-1))
for (j in (n-1):1) {
  c[j] <- zeta[j] - mu[j] * c[j+1]
  b[j] <- (y[j+1] - y[j]) / h[j] - h[j] * (c[j+1] + 2 * c[j])/3
  d[j] <- (c[j+1] - c[j]) / (3*h[j])
}

#Paso 7
resultados <- matrix(rep(NA, 4*(n-1)), nrow = (n-1), ncol = 4, byrow = F)
for (k in 1:(n-1)) {
  resultados[k, 1] <- y[k]
  resultados[k, 2] <- b[k]
  resultados[k, 3] <- c[k]
  resultados[k, 4] <- d[k]
}

print(resultados)

#Construyo el polinomio
polinomios <- rep(NA, times = nrow(resultados))
for (i in 1:nrow(resultados)) {
  polinomios[i] <- glue::glue(resultados[i,1])
  for(j in 2:ncol(resultados)){
    polinomios[i] <- polinomios[i] + glue::glue(" + ", resultados[i,j], " * (x - ", x[i], ")^", (j-1))
  }
}

return(polinomios)
}

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Métodos

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# Cargo el df
df <- data.frame("Tasa" = seq(from = 0, to = 0.1, by = 0.01), "Precio" = c(120, 114.56029, 109.42692, 105.38971, 101.35242, 97.31513, 93.27784, 89.24055, 85.20326, 81.16597, 77.12868, 73.09139, 69.05410, 65.01681, 60.97952, 56.94223, 52.90494, 48.86765, 44.83036, 40.79307, 36.75578, 32.71849, 28.68120, 24.64391, 20.60662, 16.56933, 12.53204, 8.49475, 4.45746, 0.42017, -3.61712, -7.65983, -11.70254, -15.74525, -19.78796, -23.83067, -27.87338, -31.91609, -35.95880, -40.00151, -44.04422, -48.08693, -52.12964, -56.17235, -60.21506, -64.25777, -68.30048, -72.34319, -76.38590, -80.42861, -84.47132, -88.51403, -92.55674, -96.59945, -100.64216, -104.68487, -108.72758, -112.77029, -116.81300, -120.85571, -124.89842, -128.94113, -132.98384, -137.02655, -141.06926, -145.11197, -149.15468, -153.19739, -157.24010, -161.28281, -165.32552, -169.36823, -173.41094, -177.45365, -181.49636, -185.53907, -189.58178, -193.62449, -197.66720, -201.70991, -205.75262, -209.79533, -213.83804, -217.88075, -221.92346, -225.96617, -230.00888, -234.05159, -238.09430, -242.13701, -246.17972, -250.22243, -254.26514, -258.30785, -262.35056, -266.39327, -270.43598, -274.47869, -278.52140, -282.56411, -286.60682, -290.64953, -294.69224, -298.73495, -302.77766, -306.82037, -310.86308, -314.90579, -318.94850, -322.99121, -327.03392, -331.07663, -335.11934, -339.16205, -343.20476, -347.24747, -351.29018, -355.33289, -359.37560, -363.41831, -367.46102, -371.50373, -375.54644, -379.58915, -383.63186, -387.67457, -391.71728, -395.75999, -399.80270, -403.84541, -407.88812, -411.93083, -415.97354, -420.01625, -424.05896, -428.10167, -432.14438, -436.18709, -440.22980, -444.27251, -448.31522, -452.35793, -456.40064, -460.44335, -464.48606, -468.52877, -472.57148, -476.61419, -480.65690, -484.69961, -488.74232, -492.78503, -496.82774, -500.87045, -504.91316, -508.95587, -512.99858, -517.04129, -521.08400, -525.12671, -529.16942, -533.21213, -537.25484, -541.29755, -545.34026, -549.38297, -553.42568, -557.46839, -561.51110, -565.55381, -569.59652, -573.63923, -577.68194, -581.72465, -585.76736, -589.81007, -593.85278, -597.89549, -601.93820, -605.98091, -610.02362, -614.06633, -618.10904, -622.15175, -626.19446, -630.23717, -634.27988, -638.32259, -642.36530, -646.40801, -650.45072, -654.49343, -658.53614, -662.57885, -666.62156, -670.66427, -674.70698, -678.74969, -682.79240, -686.83511, -690.87782, -694.92053, -698.96324, -703.00595, -707.04866, -711.09137, -715.13408, -719.17679, -723.21950, -727.26221, -731.30492, -735.34763, -739.39034, -743.43305, -747.47576, -751.51847, -755.56118, -759.60389, -763.64660, -767.68931, -771.73202, -775.77473, -779.81744, -783.86015, -787.90286, -791.94557, -795.98828, -800.03099, -804.07370, -808.11641, -812.15912, -816.20183, -820.24454, -824.28725, -828.32996, -832.37267, -836.41538, -840.45809, -844.50080, -848.54351, -852.58622, -856.62893, -860.67164, -864.71435, -868.75706, -872.79977, -876.84248, -880.88519, -884.92790, -888.97061, -893.01332, -897.05603, -901.09874, -905.14145, -909.18416, -913.22687, -917.26958, -921.31229, -925.35500, -929.39771, -933.44042, -937.48313, -941.52584, -945.56855, -949.61126, -953.65397, -957.69668, -961.73939, -965.78210, -969.82481, -973.86752, -977.91023, -981.95294, -985.99565, -990.03836, -994.08107, -998.12378, -1002.16649, -1006.20920, -1010.25191, -1014.29462, -1018.33733, -1022.38004, -1026.42275, -1030.46546, -1034.50817, -1038.55088, -1042.59359, -1046.63630, -1050.67901, -1054.72172, -1058.76443, -1062.80714, -1066.84985, -1070.89256, -1074.93527, -1078.97798, -1083.02069, -1087.06340, -1091.10611, -1095.14882, -1099.19153, -1103.23424, -1107.27695, -1111.31966, -1115.36237, -1119.40508, -1123.44779, -1127.49050, -1131.53321, -1135.57592, -1139.61863, -1143.66134, -1147.70405, -1151.74676, -1155.78947, -1159.83218, -1163.87489, -1167.91760, -1171.96031, -1175.99302, -1180.03573, -1184.07844, -1188.12115, -1192.16386, -1196.20657, -1200.24928, -1204.29199, -1208.33470, 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-2458.50209, -2462.54480, -2466.58751, -2470.63022, -2474.67293, -2478.71564, -2482.75835, -2486.80106, -2490.84377, -2494.88648, -2498.92919, -2502.97190, -2507.01461, -2511.05732, -2515.09503, -2519.13774, -2523.18045, -2527.22316, -2531.26587, -2535.30858, -2539.35129, -2543.39400, -2547.43671, -2551.47942, -2555.52213, -2559.56484, -2563.60755, -2567.65026, -2571.69297, -2575.73568, -2579.77839, -2583.82110, -2587.86381, -2591.90652, -2595.94923, -2600.00000, -2604.05000, -2608.10000, -2612.15000, -2616.20000, -2620.25000, -2624.30000, -2628.35000, -2632.40000, -2636.45000, -2640.50000, -2644.55000, -2648.60000, -2652.65000, -2656.70000, -2660.75000, -2664.80000, -2668.85000, -2672.90000, -2676.95000, -2681.00000, -2685.05000, -2689.10000, -2693.15000, -2697.20000, -2701.25000, -2705.30000, -2709.35000, -2713.40000, -2717.45000, -2721.50000, -2725.55000, -2729.60000, -2733.65000, -2737.70000, -2741.75000, -2745.80000, -2749.85000, -2753.90000, -2757.95000, -2762.00000, -2766.05000, -2770.10000, -2774.15000, -2778.20000, -2782.25000, -2786.30000, -2790.35000, -2794.40000, -2798.45000, -2802.50000, -2806.55000, -2810.60000, -2814.65000, -2818.70000, -2822.75000, -2826.80000, -2830.85000, -2834.90000, -2838.95000, -2843.00000, -2847.05000, -2851.10000, -2855.15000, -2859.20000, -2863.25000, -2867.30000, -2871.35000, -2875.40000, -2879.45000, -2883.50000, -2887.55000, -2891.60000, -2895.65000, -2899.70000, -2903.75000, -2907.80000, -2911.85000, -2915.90000, -2919.95000, -2924.00000, -2928.05000, -2932.10000, -2936.15000, -2940.20000, -2944.25000, -2948.30000, -2952.35000, -2956.40000, -2960.45000, -2964.50000, -2968.55000, -2972.60000, -2976.65000, -2980.70000, -2984.75000, -2988.80000, -2992.85000, -2996.90000, -3000.95000, -3005.00000, -3009.05000, -3013.10000, -3017.15000, -3021.20000, -3025.25000, -3029.30000, -3033.35000, -3037.40000, -3041.45000, -3045.50000, -3049.55000, -3053.60000, -3057.65000, -3061.70000, -3065.75000, -3069.80000, -3073.85000, -3077.90000, -3081.95000, -3086.00000, -3090.05000, -3094.10000, -3098.15000, -3102.20000, -3106.25000, -3110.30000, -3114.35000, -3118.40000, -3122.45000, -3126.50000, -3130.55000, -3134.60000, -3138.65000, -3142.70000, -3146.75000, -3150.80000, -3154.85000, -3158.90000, -3162.95000, -3167.00000, -3171.05000, -3175.10000, -3179.15000, -3183.20000, -3187.25000, -3191.30000, -3195.35000, -3199.40000, -3203.45000, -3207.50000, -3211.55000, -3215.60000, -3219.65000, -3223.70000, -3227.75000, -3231.80000, -3235.85000, -3239.90000, -3243.95000, -3248.00000, -3252.05000, -3256.10000, -3260.15000, -3264.20000, -3268.25000, -3272.30000, -3276.35000, -3280.40000, -3284.45000, -3288.50000, -3292.55000, -3296.60000, -3300.65000, -3304.70000, -3308.75000, -3312.80000, -3316.85000, -3320.90000, -3324.95000, -3329.00000, -3333.05000, -3337.10000, -3341.15000, -3345.20000, -3349.25000, -3353.30000, -3357.35000, -3361.40000, -3365.45000, -3369.50000, -3373.55000, -3377.60000, -3381.65000, -3385.70000, -3389.75000, -3393.80000, -3397.85000, -3401.90000, -3405.95000, -3410.00000, -3414.05000, -3418.10000, -3422.15000, -3426.20000, -3430.25000, -3434.30000, -3438.35000, -3442.40000, -3446.45000, -3450.50000, -3454.55000, -3458.60000, -3462.65000, -3466.70000, -3470.75000, -3474.80000, -3478.85000, -3482.90000, -3486.95000, -3491.00000, -3495.05000, -3499.10000, -3503.15000, -3507.20000, -3511.25000, -3515.30000, -3519.35000, -3523.40000, -3527.45000, -3531.50000, -3535.55000, -3539.60000, -3543.65000, -3547.70000, -3551.75000, -3555.80000, -3559.85000, -3563.90000, -3567.95000, -3572.00000, -3576.05000, -3580.10000, -3584.15000, -3588.20000, -3592.25000, -3596.30000, -3600.35000, -3604.40000, -3608.45000, -3612.50000, -3616.55000, -3620.60000, -3624.65000, -3628.70000, -3632.75000, -3636.80000, -3640.85000, -3644.90000, -3648.95000, -3653.00000, -3657.05000, -3661.10000, -3665.15000, -3669.20000, -3673.25000, -3677.30000, -3681.35000, -3685.40000, -3689.45000, -3693.50000, -3697.55000, -3701.60000, -3705.65000, -3709.70000, -3713.75000, -3717.80000, -3721.85000, -3725.90000, -3729.95000, -3734.00000, -3738.05000, -3742.10000, -3746.15000, -3750.20000, -3754.25000, -3758.30000, -3762.35000, -3766.40000, -3770.45000, -3774.50000, -3778.55000, -3782.60000, -3786.65000, -3790.70000, -3794.75000, -3798.80000, -3802.85000, -3806.90000, -3810.95000, -3815.00000, -3819.05000, -3823.10000, -3827.15000, -3831.20000, -3835.25000, -3839.30000, -3843.35000, -3847.40000, -3851.45000, -3855.50000, -3859.55000, -3863.60000, -3867.65000, -3871.70000, -3875.75000, -3879.80000, -3883.85000, -3887.90000, -3891.95000, -3896.00000, -3900.05000, -3904.10000, -3908.15000, -3912.20000, -3916.25000, -3920.30000, -3924.35000, -3928.40000, -3932.45000, -3936.50000, -3940.55000, -3944.60000, -3948.65000, -3952.70000, -3956.75000, -3960.80000, -3964.85000, -3968.90000, -3972.95000, -3977.00000, -3981.05000, -3985.10000, -3989.15000, -3993.2
```

Tasa	Precio
0.00	120.00000
0.01	114.56029
0.02	109.42692
0.03	104.57971
0.04	100.00000
0.05	95.67052
0.06	91.57527
0.07	87.69941
0.08	84.02916
0.09	80.55174
0.10	77.25528

DERIVACIÓN NUMÉRICA E INTERPOLACIÓN

Considere la tabla de tasas de interés (en tanto por uno) y Precio, suponiendo que el Precio es una función de la tasa: $\text{Precio} = P(r)$.

- Aproxime la derivada $P'(0.00)$ y $P'(0.10)$ usando el método que considere más preciso (justifique).
- Estime $P(0.095)$ mediante un Cubic Spline Natural.
- Estime $P(0.095)$ mediante un Cubic Spline Sujeto usando las derivadas estimadas en a).

[Escriba a continuación la respuesta, y cargue en el zip que entrega mediante campus el Script de R con la resolución.]

(15 puntos)

Figure 1: Consigna

```
## 2 0.01 114.56029 -513.337 (P) o -543.971 (R)
## 3 0.02 109.42692 -484.7209999999999 (P) o -513.337 (R)
## 4 0.03 104.57971 -457.9710000000001 (P) o -484.7209999999999 (R)
## 5 0.04 100.00000 -432.948 (P) o -457.9710000000001 (R)
## 6 0.05 95.67052 -409.5249999999999 (P) o -432.948 (R)
## 7 0.06 91.57527 -387.586 (P) o -409.5249999999999 (R)
## 8 0.07 87.69941 -367.025 (P) o -387.586 (R)
## 9 0.08 84.02916 -347.7420000000001 (P) o -367.025 (R)
## 10 0.09 80.55174 -329.646 (P) o -347.7420000000001 (R)
## 11 0.10 77.25528 -329.646
```

B

```
trazadores <- SplineNatural(x = df$Tasa, y = df$Precio)
```

```
##           [,1]      [,2]      [,3]      [,4]
## [1,] 120.00000 -550.5363    0.0000  65653.257
## [2,] 114.56029 -530.8403 1969.5977 -21926.283
## [3,] 109.42692 -498.0263 1311.8092  1871.876
## [4,] 104.57971 -471.2285 1367.9655 -4221.221
## [5,] 100.00000 -445.1356 1241.3289 -2256.993
## [6,] 95.67052 -420.9861 1173.6191 -2750.806
## [7,] 91.57527 -398.3390 1091.0949 -1579.784
## [8,] 87.69941 -376.9910 1043.7014 -4710.058
## [9,] 84.02916 -357.5300 902.3996  7640.015
## [10,] 80.55174 -337.1900 1131.6001 -37720.003
```

```
eval(parse(text = trazadores[10]), list(x = 0.095))
```

```
## [1] 78.88936
```

C

```
trazadores_condicionados <- SplineCondicionado(x = df$Tasa, y = df$Precio, fpo = (120 - 114.56029)/0.1,
```

```
##           [,1]      [,2]      [,3]      [,4]
## [1,] 120.00000  54.3971 -104777.34927  4494053.927
## [2,] 114.56029 -692.9337  30044.26854 -1208459.781
## [3,] 109.42692 -454.5863 -6209.52489  319605.198
## [4,] 104.57971 -482.8952  3378.63104 -88621.009
## [5,] 100.00000 -441.9089   720.00075  17608.840
## [6,] 95.67052 -422.2262  1248.26596  2185.649
## [7,] 91.57527 -396.6052  1313.83542 -41191.435
## [8,] 87.69941 -382.6859   78.09236  148800.092
## [9,] 84.02916 -336.4841  4542.09513 -566788.934
## [10,] 80.55174 -415.6788 -12461.57290  2106485.645
```

```
eval(parse(text = trazadores_condicionados[10]), list(x = 0.095))
```

```
## [1] 78.42512
```