Practica 7. Analisis de tasas de crecimento para ciudades de México

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Tabla de datos con dinámica de crecimiento de población en selección de seis ciudades de México

```
ciudad <- c("CDMX", "Guadalajara", "Zapopan", "Tlaquepaque", "Monterrey", "Puebla")
latitud <- c(19.4316, 20.6775, 20.7216, 20.6419, 25.6714, 19.051389)
longitud <- c(-99.1338, -103.3478, -103.3899, -103.3129, -100.3086, -98.217778)
p1900 <- c(0.541516, 0.101208, 0.002298, 0.004346, 0.062266, 0.093521)
p1910 <- c(0.720753, 0.119468, 0.002438, 0.004767, 0.078528, 0.096121)
p1920 <- c(0.906063, 0.143376, 0.002592, 0.005327, 0.088479, 0.095)
p1930 <- c(1.229576, 0.179556, 0.002982, 0.007603, 0.132577, 0.114793)
p1940 <- c(1.757530, 0.241, 0.003685, 0.011486, 0.186, 0.138491)
p1950 <- c(3.050442, 0.380226, 0.006144, 0.020821, 0.333422, 0.211331)
p1960 <- c(4.870876, 0.740394, 0.019138, 0.037626, 0.596939, 0.289049)
p1970 <- c(6.874165, 1.199391, 0.045292, 0.050760, 0.858107, 0.401603)
p1980 <- c(8.831079, 1.626152, 0.345390, 0.133500, 1.084696, 0.772908)
p1990 <- c(8.235744, 1.650205, 0.668323, 0.328031, 1.068996, 1.007170)
p2000 <- c(8.605239, 1.646319, 0.919690, 0.458674, 1.110909, 1.271673)
p2010 <- c(8.851080, 1.495, 1.142483, 0.575942, 1.136, 1.434062)
p2020 <- c(9.23, 1.386, 1.257547, 0.650123, 1.143, 1.542232)


## dataframe (tabla)
tabla_poblacion <- data.frame(
  ciudad = ciudad,
  latitud = latitud,
  longitud = longitud,
  p1900 = p1900,
  p1910 = p1910,
  p1920 = p1920,
  p1930 = p1930,
  p1940 = p1940,
  p1950 = p1950,
  p1960 = p1960,
  p1970 = p1970,
  p1980 = p1980,
  p1990 = p1990,
  p2000 = p2000,
  p2010 = p2010,
  p2020 = p2020
)
tabla_poblacion
```

```
##        ciudad  latitud   longitud    p1900    p1910    p1920    p1930    p1940
## 1        CDMX 19.43160  -99.13380 0.541516 0.720753 0.906063 1.229576 1.757530
## 2 Guadalajara 20.67750 -103.34780 0.101208 0.119468 0.143376 0.179556 0.241000
## 3     Zapopan 20.72160 -103.38990 0.002298 0.002438 0.002592 0.002982 0.003685
## 4 Tlaquepaque 20.64190 -103.31290 0.004346 0.004767 0.005327 0.007603 0.011486
## 5   Monterrey 25.67140 -100.30860 0.062266 0.078528 0.088479 0.132577 0.186000
## 6      Puebla 19.05139  -98.21778 0.093521 0.096121 0.095000 0.114793 0.138491
##      p1950    p1960    p1970    p1980    p1990    p2000    p2010    p2020
## 1 3.050442 4.870876 6.874165 8.831079 8.235744 8.605239 8.851080 9.230000
## 2 0.380226 0.740394 1.199391 1.626152 1.650205 1.646319 1.495000 1.386000
## 3 0.006144 0.019138 0.045292 0.345390 0.668323 0.919690 1.142483 1.257547
## 4 0.020821 0.037626 0.050760 0.133500 0.328031 0.458674 0.575942 0.650123
## 5 0.333422 0.596939 0.858107 1.084696 1.068996 1.110909 1.136000 1.143000
## 6 0.211331 0.289049 0.401603 0.772908 1.007170 1.271673 1.434062 1.542232
```

```
dim(tabla_poblacion)
```

```
## [1]  6 16
```

```
str(tabla_poblacion)
```

```
## 'data.frame':    6 obs. of  16 variables:
##  $ ciudad  : chr  "CDMX" "Guadalajara" "Zapopan" "Tlaquepaque" ...
##  $ latitud : num  19.4 20.7 20.7 20.6 25.7 ...
##  $ longitud: num  -99.1 -103.3 -103.4 -103.3 -100.3 ...
##  $ p1900   : num  0.54152 0.10121 0.0023 0.00435 0.06227 ...
##  $ p1910   : num  0.72075 0.11947 0.00244 0.00477 0.07853 ...
##  $ p1920   : num  0.90606 0.14338 0.00259 0.00533 0.08848 ...
##  $ p1930   : num  1.22958 0.17956 0.00298 0.0076 0.13258 ...
##  $ p1940   : num  1.75753 0.241 0.00368 0.01149 0.186 ...
##  $ p1950   : num  3.05044 0.38023 0.00614 0.02082 0.33342 ...
##  $ p1960   : num  4.8709 0.7404 0.0191 0.0376 0.5969 ...
##  $ p1970   : num  6.8742 1.1994 0.0453 0.0508 0.8581 ...
##  $ p1980   : num  8.831 1.626 0.345 0.134 1.085 ...
##  $ p1990   : num  8.236 1.65 0.668 0.328 1.069 ...
##  $ p2000   : num  8.605 1.646 0.92 0.459 1.111 ...
##  $ p2010   : num  8.851 1.495 1.142 0.576 1.136 ...
##  $ p2020   : num  9.23 1.39 1.26 0.65 1.14 ...
```

Visualización de tabla de datos con formato

```
knitr::kable(tabla_poblacion[,c(1,4:16)],
             digits=2,
             col.names=c("Ciudad",seq(1900, 2020, 10)),
             caption="Tabla 1. Población en centros urbanos, millones de personas")
```

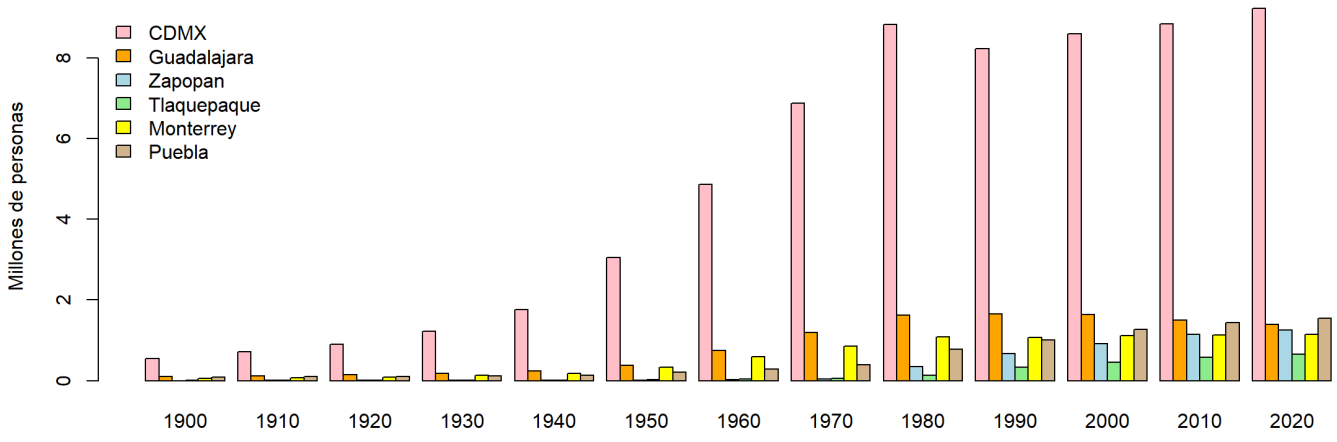
Tabla 1. Población en centros urbanos, millones de personas

Ciudad	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
CDMX	0.54	0.72	0.91	1.23	1.76	3.05	4.87	6.87	8.83	8.24	8.61	8.85	9.23
Guadalajara	0.10	0.12	0.14	0.18	0.24	0.38	0.74	1.20	1.63	1.65	1.65	1.50	1.39

Ciudad	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
Zapopan	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.35	0.67	0.92	1.14	1.26
Tlaquepaque	0.00	0.00	0.01	0.01	0.01	0.02	0.04	0.05	0.13	0.33	0.46	0.58	0.65
Monterrey	0.06	0.08	0.09	0.13	0.19	0.33	0.60	0.86	1.08	1.07	1.11	1.14	1.14
Puebla	0.09	0.10	0.10	0.11	0.14	0.21	0.29	0.40	0.77	1.01	1.27	1.43	1.54

Visualizar los datos sobre población en forma de grafica de barras

```
cd_colores <- c("pink","orange","lightblue","lightgreen","yellow","tan")

barplot(as.matrix(tabla_poblacion[,c(4:16)]),
        beside=TRUE,
        ylab="Millones de personas",
        col=cd_colores,
        names.arg=seq(1900, 2020, 10))

legend("topleft", legend=tabla_poblacion[,1],
       fill=cd_colores, bty="n")
```



Calcular las tasas de crecimiento de población

```
c_tasa <- function(p1, p2) {
  tasa <- 100 * (p2 - p1) / p1
  return(tasa)
}

t1910 <- c_tasa(tabla_poblacion[,"p1900"],tabla_poblacion[,"p1910"])
t1920 <- c_tasa(tabla_poblacion[,"p1910"],tabla_poblacion[,"p1920"])
t1930 <- c_tasa(tabla_poblacion[,"p1920"],tabla_poblacion[,"p1930"])
t1940 <- c_tasa(tabla_poblacion[,"p1930"],tabla_poblacion[,"p1940"])
t1950 <- c_tasa(tabla_poblacion[,"p1940"],tabla_poblacion[,"p1950"])
t1960 <- c_tasa(tabla_poblacion[,"p1950"],tabla_poblacion[,"p1960"])
t1970 <- c_tasa(tabla_poblacion[,"p1960"],tabla_poblacion[,"p1970"])
t1980 <- c_tasa(tabla_poblacion[,"p1970"],tabla_poblacion[,"p1980"])
t1990 <- c_tasa(tabla_poblacion[,"p1980"],tabla_poblacion[,"p1990"])
t2000 <- c_tasa(tabla_poblacion[,"p1990"],tabla_poblacion[,"p2000"])
t2010 <- c_tasa(tabla_poblacion[,"p2000"],tabla_poblacion[,"p2010"])
t2020 <- c_tasa(tabla_poblacion[,"p2010"],tabla_poblacion[,"p2020"])

tabla_tasas <- data.frame(
  ciudad = ciudad,
  latitud = latitud,
  longitud = longitud,
  t1910 = t1910,
  t1920 = t1920,
  t1930 = t1930,
  t1940 = t1940,
  t1950 = t1950,
  t1960 = t1960,
  t1970 = t1970,
  t1980 = t1980,
  t1990 = t1990,
  t2000 = t2000,
  t2010 = t2010,
  t2020 = t2020
)
```

Visualización de tabla de datos con formato

```
knitr::kable(tabla_tasas[,c(1,4:15)],
             digits=1,
             col.names=c("Ciudad",seq(1910, 2020, 10)),
             caption="Tabla 2. Tasas de crecimiento en centros urbanos, %")
```

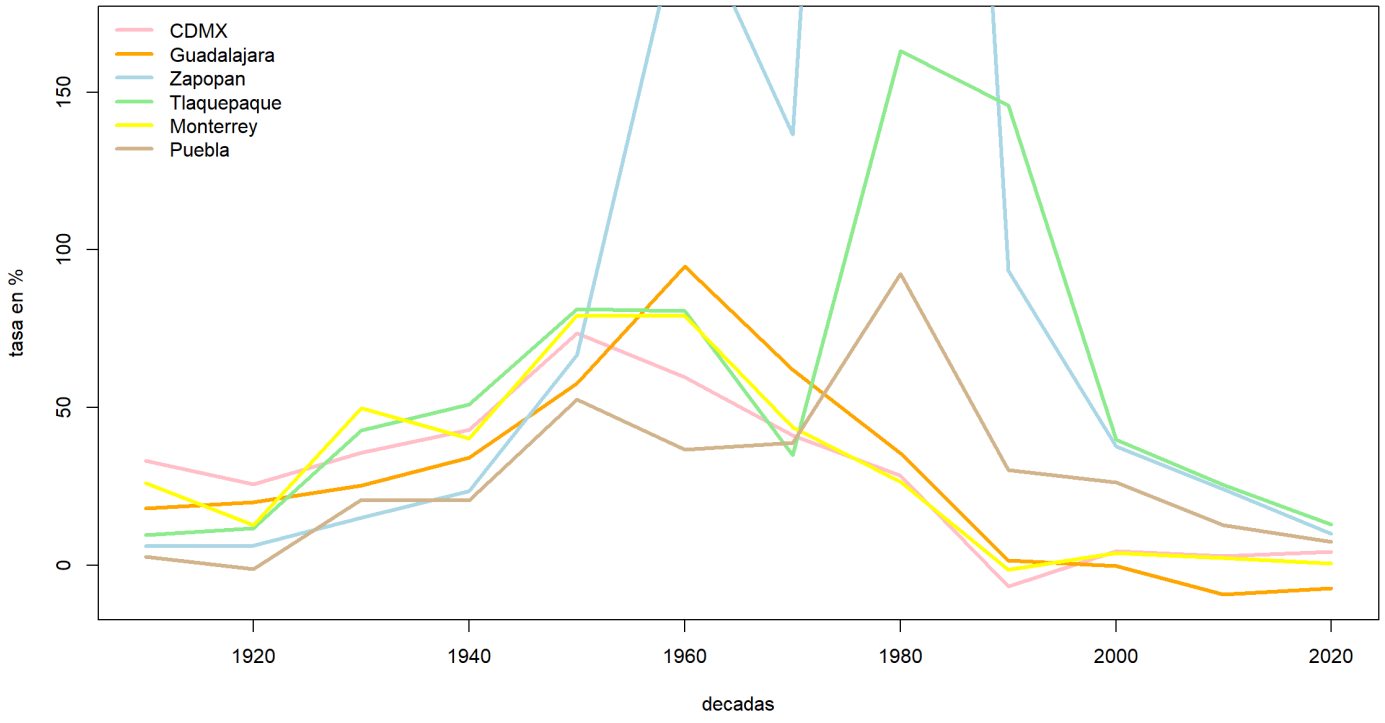
Tabla 2. Tasas de crecimiento en centros urbanos, %

Ciudad	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
CDMX	33.1	25.7	35.7	42.9	73.6	59.7	41.1	28.5	-6.7	4.5	2.9	4.3
Guadalajara	18.0	20.0	25.2	34.2	57.8	94.7	62.0	35.6	1.5	-0.2	-9.2	-7.3
Zapopan	6.1	6.3	15.0	23.6	66.7	211.5	136.7	662.6	93.5	37.6	24.2	10.1
Tlaquepaque	9.7	11.7	42.7	51.1	81.3	80.7	34.9	163.0	145.7	39.8	25.6	12.9

Ciudad	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020
Monterrey	26.1	12.7	49.8	40.3	79.3	79.0	43.8	26.4	-1.4	3.9	2.3	0.6
Puebla	2.8	-1.2	20.8	20.6	52.6	36.8	38.9	92.5	30.3	26.3	12.8	7.5

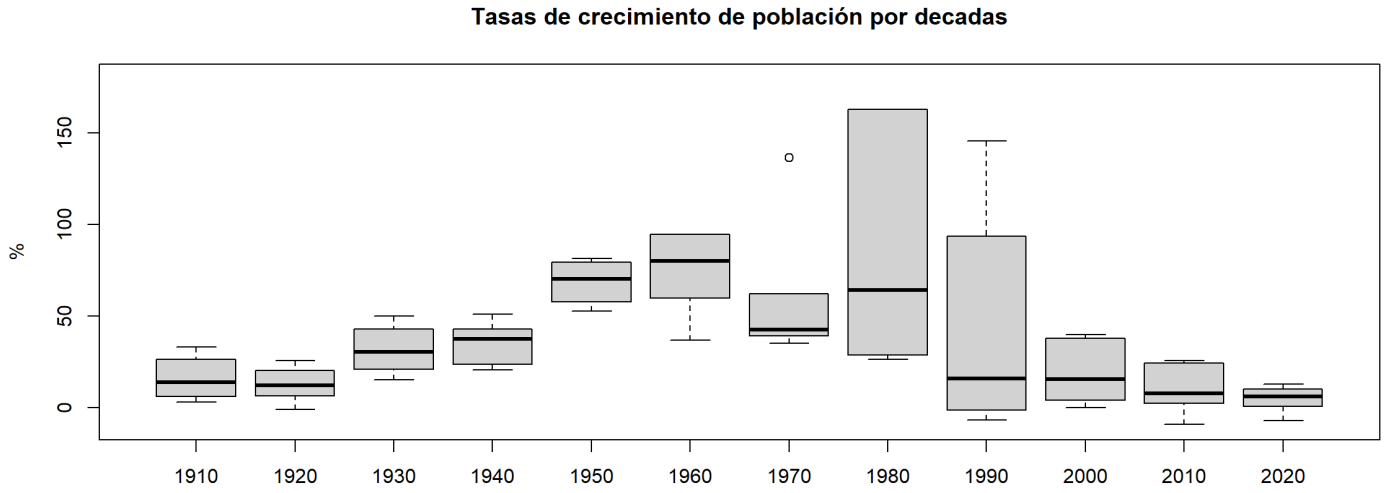
Visualizar datos sobre las tendencias de crecimiento de población en forma gráfica

```
decadas <- seq(1910, 2020, 10)

plot(x=decadas, y=tabla_tasas[1,4:15],
     type="l", lwd=3, col=cd_colores[1],
     ylab="tasa en %", ylim=c(-10, 170))
lines(x=decadas, y=tabla_tasas[2,4:15], col=cd_colores[2], lwd=3)
lines(x=decadas, y=tabla_tasas[3,4:15], col=cd_colores[3], lwd=3)
lines(x=decadas, y=tabla_tasas[4,4:15], col=cd_colores[4], lwd=3)
lines(x=decadas, y=tabla_tasas[5,4:15], col=cd_colores[5], lwd=3)
lines(x=decadas, y=tabla_tasas[6,4:15], col=cd_colores[6], lwd=3)

legend("topleft", legend=tabla_tasas[,1],
       col=cd_colores, lwd=3, bty="n")
```



Representar resumen grafico de tasas de crecimiento por decadas

```
boxplot(tabla_tasas[,4:15],
        names=decadas,
        main="Tasas de crecimiento de población por decadas",
        ylab="%", ylim=c(-10, 180))
```



Pruebas de hipotesis sobre existencia de diferencias estadisticas entre muestras

```
t.test(tabla_tasas[,"t1910"], tabla_tasas[,"t1950"])
```

```
##
##  Welch Two Sample t-test
##
## data:  tabla_tasas[, "t1910"] and tabla_tasas[, "t1950"]
## t = -7.7291, df = 9.9933, p-value = 1.596e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -67.71639 -37.40832
## sample estimates:
## mean of x mean of y
##  15.96960  68.53195
```

```
t.test(tabla_tasas[,"t1910"], tabla_tasas[,"t2020"])
```

```
##
##  Welch Two Sample t-test
##
## data:  tabla_tasas[, "t1910"] and tabla_tasas[, "t2020"]
## t = 1.9786, df = 8.2653, p-value = 0.08208
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.794746 24.367099
## sample estimates:
## mean of x mean of y
## 15.969599  4.683423
```

```
t.test(tabla_tasas[,"t2010"], tabla_tasas[,"t2020"])
```

```
##
##  Welch Two Sample t-test
##
## data:  tabla_tasas[, "t2010"] and tabla_tasas[, "t2020"]
## t = 0.80215, df = 7.6282, p-value = 0.4467
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -9.618608 19.746887
## sample estimates:
## mean of x mean of y
##  9.747562  4.683423
```

```
t.test(tabla_tasas[,"t2000"], tabla_tasas[,"t2020"])
```

```
##
##  Welch Two Sample t-test
##
## data:  tabla_tasas[, "t2000"] and tabla_tasas[, "t2020"]
## t = 1.7523, df = 6.5717, p-value = 0.126
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -5.131032 33.054787
## sample estimates:
## mean of x mean of y
## 18.645300  4.683423
```

```
t.test(tabla_tasas[,"t1990"], tabla_tasas[,"t2020"])
```

```
##
##  Welch Two Sample t-test
##
## data:  tabla_tasas[, "t1990"] and tabla_tasas[, "t2020"]
## t = 1.5267, df = 5.1361, p-value = 0.1858
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -26.2256 104.4633
## sample estimates:
## mean of x mean of y
## 43.802286  4.683423
```

```
t.test(tabla_tasas[,"t1980"], tabla_tasas[,"t2020"])
```

```
##
##  Welch Two Sample t-test
##
## data:  tabla_tasas[, "t1980"] and tabla_tasas[, "t2020"]
## t = 1.6135, df = 5.0086, p-value = 0.1675
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -96.78678 423.58590
## sample estimates:
##  mean of x  mean of y
## 168.082986   4.683423
```

```
t.test(tabla_tasas[,"t1970"], tabla_tasas[,"t2020"])
```

```
##
##  Welch Two Sample t-test
##
## data:  tabla_tasas[, "t1970"] and tabla_tasas[, "t2020"]
## t = 3.3953, df = 5.3488, p-value = 0.01742
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  14.13279 95.62667
## sample estimates:
## mean of x mean of y
## 59.563150  4.683423
```

```
t.test(tabla_tasas[,"t1960"], tabla_tasas[,"t2020"])
```

```
##
##  Welch Two Sample t-test
##
## data:  tabla_tasas[, "t1960"] and tabla_tasas[, "t2020"]
## t = 3.5459, df = 5.1417, p-value = 0.01571
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##   25.02545 153.07926
## sample estimates:
## mean of x mean of y
## 93.735776  4.683423
```

```
wilcox.test(tabla_tasas[,"t1910"], tabla_tasas[,"t1950"])
```

```
##
##  Wilcoxon rank sum exact test
##
## data:  tabla_tasas[, "t1910"] and tabla_tasas[, "t1950"]
## W = 0, p-value = 0.002165
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(tabla_tasas[,"t1910"], tabla_tasas[,"t2020"])
```

```
##
##  Wilcoxon rank sum exact test
##
## data:  tabla_tasas[, "t1910"] and tabla_tasas[, "t2020"]
## W = 27, p-value = 0.1797
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(tabla_tasas[,"t2010"], tabla_tasas[,"t2020"])
```

```
##
##  Wilcoxon rank sum exact test
##
## data:  tabla_tasas[, "t2010"] and tabla_tasas[, "t2020"]
## W = 21, p-value = 0.6991
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(tabla_tasas[,"t2000"], tabla_tasas[,"t2020"])
```

```
##
##  Wilcoxon rank sum exact test
##
## data:  tabla_tasas[, "t2000"] and tabla_tasas[, "t2020"]
## W = 24, p-value = 0.3939
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(tabla_tasas[,"t1990"], tabla_tasas[,"t2020"])
```

```
##
##  Wilcoxon rank sum exact test
##
## data:  tabla_tasas[, "t1990"] and tabla_tasas[, "t2020"]
## W = 22, p-value = 0.5887
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(tabla_tasas[,"t1980"], tabla_tasas[,"t2020"])
```

```
##
##  Wilcoxon rank sum exact test
##
## data:  tabla_tasas[, "t1980"] and tabla_tasas[, "t2020"]
## W = 36, p-value = 0.002165
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(tabla_tasas[,"t1970"], tabla_tasas[,"t2020"])
```

```
##
##  Wilcoxon rank sum exact test
##
## data:  tabla_tasas[, "t1970"] and tabla_tasas[, "t2020"]
## W = 36, p-value = 0.002165
## alternative hypothesis: true location shift is not equal to 0
```

```
wilcox.test(tabla_tasas[,"t1960"], tabla_tasas[,"t2020"])
```

```
##
##  Wilcoxon rank sum exact test
##
## data:  tabla_tasas[, "t1960"] and tabla_tasas[, "t2020"]
## W = 36, p-value = 0.002165
## alternative hypothesis: true location shift is not equal to 0
```

Ejemplo de grafica de tasas de crecimiento en un periodo

```
barplot(tabla_tasas[,"t2020"],
        names.arg=tabla_tasas[,1],
        main="Crecimiento en 2010-2020",
        ylab="%", col=cd_colores)
abline(h=0)
```